LWS / SDO Workshop

The Many Spectra of Solar Activity

Resort at Squaw Creek, Squaw Valley, CA

May 1 - 5, 2011

Modeling the Physical Connection Between the Solar Convection Zone and Corona

Author(s): W.P. Abbett
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Tuesday May 3, 2011 8:30-9:00am

How magnetic energy and flux emerges from below the surface into the solar atmosphere is a topic ripe for theoretical and observational investigation in the era of SDO. Data from this mission is showing us that magnetic fields from the interior emerge through the surface, and energize the dynamic chromosphere and corona over a wide range of spatial and temporal scales. The interplay between granular scale magnetic features, and large-scale structures from decaying active regions, for example, are seen to affect large-scale magnetic topology in complex ways. Being able to model these interactions in a way that captures the disparate spatial and temporal scales of the system and and allows a more direct comparison with observations would be of enormous utility in the effort to understand, e.g., the physics of coronal heating, the energetics of the solar wind, and the onset of magnetic eruptions (among other phenomena). In this talk, we will summarize current progress in the efforts to model the complex magnetic and energetic connections between the turbulent convective interior and the magnetically dominated corona, and we will present an analysis of the flux of electromagnetic energy from below the surface out into the corona in a model coronal hole region.

Super-Diffusivity in the Quiet Sun Photosphere as Derived from SDO/HMI and NST Observations

Author(s): Valentyna Abramenko, Vasyl Yurchyshyn, Philip Goode, Vincenzo Carbone
Affiliation(s): Big Bear Solar Observatory

Monday May 2, 2011 Poster #27

Diffusion of magnetic fields over the solar surface is one of the essential mechanisms linked to global magnetic properties of the Sun. Diffusion at large spatial scales is manifested in meridional flows related to the solar cycle and the global dynamo. Diffusion at small scales is one of the key processes to understand the small-scale surface dynamo. To study the diffusion process, long-time observations of hight cadence and high spatial resolution are needed. SDO/HMI magnetograms were utilized in this study to probe magnetic diffusion on spatial scales from 0.6 to 3.3 Mm (from 14 minutes to 4.3 hours). We calculated average squared displacements of magnetic elements and found them to be proportional to the time interval in power 1.2, which indicates on the presence of a super-diffusion regime in the solar photosphere. The corresponding diffusion coefficient non-linearly increases with spatial and temporal scales from 119 to 212 km^2/s. The obtained displacement spectrum ensures diffusivity of 500-600 km^2/s at super-granular scales. This magnitude of magnetic diffusivity is necessary for successful performance of the meridional flow model. To probe the diffusion regime at smaller scales, we utilized magnetic bright points displacements obtained from the New Solar Telescope data installed at Big Bear Solar Observatory. The NST data also revealed a super-diffusion regime at smaller scales. However, the displacement spectrum was steeper in this case with the power index of 1.5 inside the scale interval from 25 to 500 km (from 10 seconds to 10 minutes). The coefficient of turbulent magnetic diffusion increases with scales from 19 to 157 km^2/s. The reported here diminution of diffusivity at smaller scales is a physical condition that is highly favourable for the small-scale turbulent dynamo action.

Multi-fractal Spectra of Solar Magnetic Fields: New Progress with HMI

Author(s): Valentyna Abramenko
Affiliation(s): Big Bear Solar Observatory

Tuesday May 3, 2011 Poster #40

SOHO/MDI instrument has made great contribution to our understanding of the multi-scale structure of solar magnetic fields by supplying us with valuable high resolution data. However, poor time resolution and fixed FOV hindered time-dependent studies of multi-scale parameters. The new SDO/HMI instrument allows us to address these temporal variations practically without restrictions. Moreover, higher sensitivity, lower noise level and the smaller pixel size of HMI images improve our estimations of multi-scale parameters. Here we compare spectra of multi-fractality of the solar magnetic field recorded for the same areas on the Sun using the MDI/HR and HMI instruments. We find that the multi-fractal properties are better pronounced in HMI data. The most significant difference in the spectra is detected at small spatial scales: while at scales below 4-5 Mm, MDI does not detect any multi-scale properties, HMI data, instead, displays multi-fractal and multi-scale organization of the magnetic field. The time variations of the HMI multi-fractal spectrum also show intriguing variations before a flare onset.

DEM Analysis Using a Multi-Stranded Loop and SDO/AIA

Author(s): Caroline Alexander, Robert Walsh, Mark Weber and Aveek Sarkar
Affiliation(s): University of Central Lancashire

Monday May 2, 2011 1:44-2:02pm

The study of coronal loops was propelled into a previously unprecedented level of detail last year with the launch of SDO. The high spatial resolution of AIA in particular, allows us to see loops with much finer detail - potentially making it possible to answer some of the open questions about loops that we are working to answer today. The Differential Emission Method (DEM) is one way in which we can utilize AIA to try to understand what is happening

within the plasma in coronal loops. In this work we present a combination of theory and observation, using DEM. We use our model of a short (10Mm), multi-stranded, nanoflare heated loop, where each strand is modeled by a one-dimensional hydrodynamic simulation, to create full-solution DEMs. Using our model and the temperature response of AIA, we create 'observations' against which to test two types of DEM solver – one using an iterative method, and the other, a new method from Mark Weber called Convexhull. Since we know every detail of our model, we can see how accurately these methods recreate the DEM. We have also looked at real AIA data to create DEM plots in order to see what we can infer about the plasma with reference to our model.

Connection Between Up-flow and Down-flow Chromospheric Events, Emitted Oscillations and Photospheric Dynamics

Author(s): Aleksandra Andic

Affiliation(s): Big Bear Solar Observatory

Wednesday May 4, 2011 Poster #80

Two chromospheric events and their connection to the oscillations and the photospheric dynamics were analysed. The observations were done at New Solar Telescope at Big Bear Solar Observatory using photometry in the TiO spectral line, with the FISS spectrograph scanning Ca II and H-alpha spectral lines. Event in Ca II showed strong plasma flows and propagating oscillations in the chromosphere. The movement of the footprints of the flux tubes in photosphere indicated a possible flux tube entanglement and magnetic reconnection causing observed Ca II brightening and oscillations that propagate in the chromosphere. The down-flow event in H-alpha showed upward oscillatory propagation. The photospheric oscillations were not clearly connected with either up-flow or down-flow event. However, the closeness and simultaneous appearance of the both events indicate possible connection between these events in the upper atmospheric layers that were not covered with the optical formation heights of the used spectral lines.

Observation of Reconnection Inflow/Outflow and Waves Associated with the 2010 August 18 Flare

Author(s): A. Asai, S. Takasao, H. Isobe, K. Shibata

Affiliation(s): Kyoto University

Wednesday May 4, 2011 1:08-1:26pm

We report, for the first time, detailed features of the 2010 August 18 flare that clearly showed reconnection inflow/outflow simultaneously with SDO/AIA. During the impulsive phase of the over-the-limb flare, we clearly observed a Y-shaped structure formed with a current sheet beneath Petschek-type slow shocks. In the current sheet, many plasmoids are formed and ejected with the velocity of about 200 – 400 km/s. We also observed plasma flows into the current sheet with the velocity of about 10 – 80 km/s. After the appearance of the Y-shaped structure, EUV waves were seen propagate along the solar surface with the velocity of about 1000 km/s. This very large velocity indicates that the EUV waves are associated with MHD fast mode, while we did not find any clear evidences of shocks like Moreton waves or type-II radio bursts.

Automated Temperature and Emission Measure Analysis of Coronal Loops and Active Regions Observed with AIA/SDO

Author(s): Markus J. Aschwanden, P. Boerner, C.J.Schrijver, and A. Malanushenko

Affiliation(s): Solar and Astrophysics Lab., LMSAL, ATC

Monday May 2, 2011 1:26-1:44pm

We developed numerical codes designed for automated analysis of AIA/SDO six-filter image datasets, including: (i) coalignment test between different wavelengths with measurements of the altitude of the EUV-emitting chromosphere, (ii) self-calibration by empirical correction of instrumental response functions, (iii) automated generation of differential emission measure (DEM) peak temperature maps T_p and emission measure maps EM_p of the full Sun or active region areas, (iv) composite DEM distributions $dEM(T)/dT$ of active regions or subareas; (v) automated detection of coronal loops, and (vi) automated background subtraction and DEM analysis of coronal loops, which yields statistics of loop temperatures T_e, temperature widths σ_T, emission measures EM, electron densities n_e, and loop widths w. The combination of these numerical codes allows for automated and objective processing of a large number of coronal loops. As an example, we present the results of an application to the active region NOAA 1158, observed on 2011-Feb-15, shortly before it produced the largest (X2.2) flare during the current solar cycle. We detect a number of 570 loops at temperatures in the entire range of $log(T_e)$=5.7-7.0 K and corroborate previous TRACE and AIA results on their near-isothermality and the validity of the Rosner-Tucker-Vaiana (RTV) law at soft X-ray temperatures ($T \approx 2$ MK) and its failure at cooler EUV temperatures.

The Impacts of Space Weather on Society and the Economy

Author(s): Daniel N. Baker

Affiliation(s): Univ. of Colorado

Monday May 2, 2011 9:00-9:30am

In this talk we describe possible extreme space weather impacts and their economic and societal costs. Modern society depends heavily on a variety of technologies that are vulnerable to the effects of intense geomagnetic storms and solar energetic particle (SEP) events. Strong currents flowing in the ionosphere can disrupt and damage Earth-based electric power grids and contribute to the accelerated

corrosion of oil and gas pipelines. Magnetic storm-driven ionospheric disturbances interfere with high-frequency radio communications and navigation signals from Global Positioning System (GPS) satellites. Exposure of spacecraft to solar particles and radiation belt enhancements can cause temporary operational anomalies, damage critical electronics, degrade solar arrays, and blind optical systems such as imagers and star trackers. Moreover, intense SEP events present a significant radiation hazard for astronauts during the high-latitude seg ment of the International Space Station (ISS) orbit as well as for future human explorers of the Moon and Mars. In addition to such direct effects as spacecraft anomalies or power grid outages, a thorough assessment of the impact of severe space weather events on present-day society must include the collateral effects of space-weather-driven technology failures. For example, polar cap absorption events due to solar particles can degrade – and, during severe events, completely black out – radio communications along transpolar aviation routes, requiring aircraft flying these routes to be diverted to lower latitudes. This can add considerable cost to the airlines and can greatly inconvenience passengers. Modern technological society is characterized by a complex set of interdependencies among its critical infrastructures. A complete picture of the socioeconomic impact of severe space weather must include both direct as well as collateral effects of space-weather-driven tech nology failures on dependent infrastructures and services.

An Overview of the Disambiguation Module for the HMI Pipeline

Author(s): G. Barnes(1), K.D. Leka(1), A.D. Crouch(1), and X. Sun(2)

Affiliation(s): (1) NWRA/CoRA; (2) Stanford University

Wednesday May 4, 2011 Poster #127

We present an overview of the algorithm used for resolving the 180 degree ambiguity in the vector magnetic field observations made by the HMI. In areas of strong transverse field, the algorithm is based on the minimum energy approach, which globally minimizes the sum of the absolute value of the vertical current density plus an approximation to the divergence of the magnetic field; in areas of weak transverse field several options are available. The algorithm uses planar geometry for active region patches, but incorporates spherical geometry when applied to the full disk. Results of the method are shown for both HMI data and tests on synthetic data.

Flat Fields of HMI images

Author(s): John Beck

Affiliation(s): Stanford/UCLA

Wednesday May 4, 2011 Poster #123

We investigate instrumental artifacts in HMI images, with an eye to improve the data quality for direct Doppler measurements as well as Intensity, Line Depth and Line Width studies.

Latitudinal Dependence of the Dynamics of the Small Magnetic Elements in the Quiet Sun from SDO/HMI

Author(s): E.E. Benevolenskaya

Affiliation(s): Pulkovo Astronomical Observatory, 196140, Saint Petersburg, Russia

Monday May 2, 2011 Poster #31

The small-scale magnetic field has a tendency to cluster in the large-scale magnetic features. Using the uniform SDO/HMI data set of line-of-sight component of the magnetic field the dynamics of the clusters of these small-scale magnetic elements have been investigated. The results show the variability in the latitudinal distribution due to the supergranulation and the meridional circulation. Also, we have estimated the rotation rate of the magnetic field and it is shown how the data filtering affects the results.

Magneto-thermal Convection in Quiescent Prominences

Author(s): Thomas Berger, Paola Testa, Andrew Hillier, Paul Boerner, B. C. Low

Affiliation(s): LMSAL, SAO, Kyoto Univ., LMSAL, HAO

Wednesday May 4, 2011 4:36-4:52pm

We analyze simultaneous SDO/AIA and Hinode/SOT images of quiescent prominence "bubble" events to show that the bubbles are at temperatures of at least 250,000 K and more likely 1.2 MK as they rise into the prominence. The resulting thermal and magnetic buoyancy drives Rayleigh-Taylor instabilities on the bubble boundaries to produce turbulent mixing plumes that transport hot plasma, magnetic flux, and presumably helicity into the overlying coronal cavities. The finding identifies the first instance of turbulent convection in the outer solar atmosphere and supports theories of CME production in which the gradual build-up of magnetic flux and helicity in coronal cavities leads to eventual destabilization and eruption of coronal flux ropes.

Twisting Motions in Sunspot Penumbrae: Evidence for Overturning Convection from the Comparison of Observations with Simulations

Author(s): Lokesh Bharti, Robert Cameron, Johann Hirzberger and Sami K. Solanki

Affiliation(s): Max-Planck Institute for Solar System Research

Tuesday May 3, 2011 10:18-10:36am

A central question related to sunspots is how sufficient energy can be transported through a strongly magnetized atmosphere, to keep the penumbra as bright as it is. It is generally assumed that some form of magnetoconvection

exists in penumbrae, acting in conjunction with the complex structuring of the magnetic and flow fields . Recently, 3D radiative MHD simulations have provided support for this conjecture, complemented by indirect evidence glanced from Hinode and SST observations. Thus, in previous studies, in sunspots located away from disk center, filaments oriented roughly parallel to the limb display a "twisting" motion that is always directed from the limb-side to the center-side of the filament. This "twisting" motion is best interpreted in terms of overturning convection, whereby only the flows directed towards the observer are seen. We investigated twisting motions in filaments at disk center in both, observations and MHD simulations, with the aim of better establishing the presence of penumbral convection and of probing its properties. We find twisting motions in filaments that are oriented in all azimuthal directions. Some filaments show twisting motions toward both the edges of the filaments which can be interpreted as upflowing gas along the axes of these filaments moving to the sides where it flows down again. The twist speed at disk center is the same as found for sunspots away from disk center. Comparison with MHD simulations show similar twisting motions and speed in filaments. These findings suggest small scale convective motions in filaments. Analysis of MDI data display a weak dependence of the penumbral brightness on sunspot size. Observations from HMI with higher resolution and cadence, this dependence can be studied in more detail.

Testing Local Helioseismology Using Synthetic Data

Author(s): A.C. Birch(1), D.C. Braun(1), A.D. Crouch(1), C. Clack(1), M. Rempel(2)

Affiliation(s): (1) NWRA, CoRA Division; (2) HAO, NCAR

Tuesday May 3, 2011 Poster #47

Synthetic data provide an important tool for testing local helioseismology. Using semi-analytical methods we compute time-distance wave travel times for laterally homogeneous magnetic problems. We will discuss the conditions under which inversions can recover the true solution (including the magnetic field strength) within reasonable limits. We also show that helioseismic holography measurements of realistic magnetoconvection simulations of sunspots are similar to measurements made from HMI observations. Simple wave-speed inversions of the measurements from the magnetoconvection simulations do not recover the true subsurface structure of the model sunspot. We acknowledge support from NASA contracts NNH09CE41C, NNG07EI51C, and NNH09CF68C.

Calculating Flaring Potential in Solar Active Regions Using SDO/HMI Vector Magnetic Field Data

Author(s): M.G. Bobra(1), M.K. Georgoulis(2), J.T. Hoeksema(1)

Affiliation(s): (1) Stanford University; (2) Academy of Athens

Wednesday May 4, 2011 Poster #105

In this study, we calculate several metrics of the flaring potential in solar active regions from the magnetic vector field, B, using vector magnetogram data from the Helioseismic and Magnetic Imager (HMI) aboard the Solar Dynamics Observatory (SDO). Specifically, we calculate all of the scalar parameters described in Leka and Barnes, 2003 (Papers I and II). We also calculate two additional parameters: the Gradient-Weighted Inversion Line Length, or GWILL, (Mason & Hoeksema, 2010) and B_effective (Georgoulis & Rust, 2007) -- both topological parameters that take the geometry of the Polarity Inversion Line (PIL) into account. Both the GWILL and B_effective parameters were computed using data from SoHO/MDI. We investigate whether extending the analysis to a vector field enables us to derive improved near real-time indicators of flare occurrence. Before HMI, the availability of vector magnetograms was sparse at best. HMI provides continuous vector magnetogram data at a 12-minute cadence. As such, this study represents the first parametrization using continuous vector magnetic field data from SDO. We note that there are already several sizable flares adequately observed by SDO that can provide grounds for case studies. The most prominent of these events are the X2.2 flare of 2011/02/15 and the X1.1 event of 2011/03/09.

Update on the AIA Wavelength and Temperature Response Functions

Author(s): Paul Boerner(1), Karel Schrijver(1), Paola Testa(2), Harry Warren(3), Mark Weber(2)

Affiliation(s): (1) Lockheed Martin Solar and Astrophysics Laboratory; (2) Smithsonian Astrophysical Observatory; (3) Naval Research Laboratory

Wednesday May 4, 2011 Poster #120

We present an assessment of the accuracy of the calibration measurements and atomic physics models that go into calculating the SDO/AIA response as a function of wavelength and temperature. The wavelength response is tested by convolving SDO/EVE and Hinode/EIS spectral data with the AIA effective area functions and comparing the predictions with AIA observations. For most channels, the AIA intensities summed over the disk are in good agreement with the corresponding measurements derived from the latest version of the EVE data. This agreement indicates that the AIA effective areas are generally stable in time. The AIA 304Å channel, however, does show degradation over the course of the mission. We also find some inconsistencies in the 335Å passband, likely due to an overestimate of the second order effective area peaks. The intensities in the AIA 193Å channel are in agreement with the corresponding measurements from EIS over the full CCD and selected subregions. Analysis of high-resolution X-ray spectra of the solar-like corona of Procyon, and of EVE spectra, allows us to investigate the accuracy and completeness of the CHIANTI database in the AIA shorter wavelength passbands. We find that in both the 94Å and

131Å channels, the spectral models significantly underestimate the plasma emission. We provide an empirical correction for the AIA temperature responses.

The Many Spectra of the HMI Ring-Diagram Pipelines

Author(s): R.S. Bogart(1), C.S. Baldner(2), S. Basu(2), D. Haber(3), R. Howe(4), O. Burtseva(4), I. Gonzalez Hernandez(4), F. Hill(4), K. Jain(4), M.C. Rabello-Soares(1), S. Tripathy(4)

Affiliation(s): (1) Stanford University, Stanford, CA; (2) Yale University, New Haven, CT; (3) Univ. of Colorado, Boulder, CO; (4) National Solar Observatory, Tucson, AZ

Wednesday May 4, 2011 Poster #131

The HMI analysis pipeline for determination of sub-surface flows has been running for nearly six months, and virtually all HMI Doppler data from the beginning of the mission have been analyzed. Over 1.75 million local-area power spectra of regions of various sizes have been produced and fitted, and inversions for the depth structure of flows have been produced for over 60,000 of the larger regions. The pipeline for determination of the sub-surface thermal structure is still under active development, with test results available for analysis for a number of strong active regions. We describe the ring-diagram pipelines, report on their performance as part of the overall HMI data analysis pipeline, describe the data products available, and discuss outstanding problems and issues for further development.

The Many Spectra of Local Helioseismology: Comparing Flows Inferred from Ring-diagram and Time-distance Analysis

Author(s): R.S. Bogart(1), J. Zhao(1), D.A. Haber(2), R. Howe(3), A.G. Kosovichev(1), S. Tripathy(3)

Affiliation(s): (1) Stanford University; (2) Univ. Of Colorado; (3) National Solar Observatory

Wednesday May 4, 2011 Poster #132

The spatial structure and temporal evolution of the solar near-surface flow fields, including differential rotation, torsional oscillations, and meridional circulation, are determined independently from HMI Doppler and other data using the techniques of ring-diagram (Bogart *et al*.) and time-distance (Zhao e*t al*.) analysis. With more than six months of data available covering the phase of rapid rise of solar activity, we present initial results comparing the flow fields inferred from the two analysis techniques for the same times and locations.

EUV and HXR Spectra and Images of a C6 Flare

Author(s): J. W. Brosius(1), G. D. Holman(2)

Affiliation(s): (1) Catholic University at NASA GSFC, Greenbelt, MD; (2) NASA GSFC, Greenbelt, MD

Wednesday May 4, 2011 11:30-11:48am

A series of C-class flares was observed on 2011 February 15 with RHESSI, CDS, and AIA. Here we focus on the C6 event around 20:30 UT. CDS spectra of the flare loop's eastern footpoint were obtained in stare mode at 10 s cadence, and include emission lines of He I, He II, O III, O V, Si XII, and Fe XIX. Light curves derived from the AIA EUV images and the CDS spectra show several bursts during an interval of relatively flat HXR emission prior to the flare's decline, suggesting ongoing magnetic reconnection. Two components appear in the O V emission line profile (formed around 0.25 MK) during this time. Upward velocities approaching 300 km/s are measured in a blueshifted component whose intensity briefly rivals that of the main component, while downward velocities in excess of 40 km/s are measured in the main component.

Comparison of Vector Magnetograms from the Solenoidal and Irrotational Components of the Magnetic Field

Author(s): Paul Bryans

Affiliation(s): NASA/GSFC and ADNET Systems, Inc.

Monday May 2, 2011 Poster #11

According to the Helmhotz Theorem, the solar magnetic field can be defined in terms of an irrotational and a solenoidal component. We will discuss the partitioning of the field into these components as a means of attributing elements of the magnetic field to its vorticity and divergence. We will then discuss the advantages of this decomposition as a metric for comparing vector magnetograms of varying spatial and temporal resolution.

Automated Detection of Filaments from SDO Data

Author(s): E. Buchlin, C. Mercier, C., J.-C. Vial

Affiliation(s): Institut d'Astrophysique Spatiale

Thursday May 5, 2011 10:18-10:36am

For space weather applications, it is important to understand filaments evolution and especially their eruptions associated with Coronal Mass Ejections. In view of the cadence and continuity of SDO observations, AIA and HMI offer a unique tool for such a program. Because of the data volume and the requirement of short latency, only an automated detection can be worked out. We present a new code for the automated detection and tracking of filaments, based on curvelet analysis of AIA 30.4 nm He II images. We also use the magnetic field measured by HMI in order to refine the results. The code is still in development, but we can already discuss what are the best algorithms (among those we have tried) and parameters to use for filament detection. We also compare the efficiency and selectivity of this code with other filament detection codes.

Is the Sun's Shape Variable?

Author(s): R. I. Bush, M. Emilio, J. R. Kuhn, I. Scholl
Affiliation(s): Institute for Astronomy, UH

Monday May 2, 2011 4:18-4:36pm

The HMI limb astrometry measurements are far more stable than the MDI limb data. Here we report on the first few SDO roll calibration datasets and use these data to interpret claims that the solar oblateness may be time variable.

HMI Vector Field Results - and Why a Year down the Line We Have Not Made the Data Available for Science Analysis

Author(s): R. Centeno(1), S. Tomczyk(1), G. Barnes(2), J. Borrero(3), S. Couvidat(4), K. Hayashi(4), T. Hoeksema(4), K.D. Leka(2), Y. Liu(4), J. Schou(4), P. Schuck(5), X. Sun(4)
Affiliation(s): (1) High Altitude Observatory, Boulder, CO; (2) CoRA, NorthWest Research Associates, Boulder, CO; (3) Kipenheuer Institut fur Sonnenphysik, Freiburg, Germany; (4) Stanford University, Stanford, CA; (5) NASA Goddard Space Flight Center, Maryland

Tuesday May 3, 2011 2:02-2:20pm

A year after SDO's launch, the HMI vector magnetic field data (i.e. full Stokes inversions and derived products calculated further down the pipeline) have not been made publicly available to the solar community. Before allowing an extended use, the HMI team has to make sure that the data meet the highest scientific standards, and that any known issue is tracked down, accounted for and properly documented. This is not an easy task. In this talk I will focus on the spectral line inversion products and their limitations derived from the nature of the instrument, the constraints of the modeling, the inversion code itself and the trade-offs and compromises that we have to make in order to keep up with the vast data volume.

On Measuring Deep Meridional Flows with Ring-Diagrams

Author(s): S. Chakraborty, R. S. Bogart, M. C. Rabello-Soares
Affiliation(s): Stanford University

Wednesday May 4, 2011 Poster #133

With the launch of the Solar Dynamics Observatory (SDO) we now have access to images of the Sun taken continuously, combining unprecedented spatial and temporal resolution. Meridional circulation, an important component in flux-transport solar-dynamo models, is one of the keys to understanding the solar cycle. In this work we present preliminary attempts at evaluating the constraints of ring-diagram analysis in measuring meridional flows in the convection zone of the Sun by analyzing data from the Helioseismic and Magnetic Imager (HMI) aboard SDO. We calculate temporal and spatial averages of the power spectra of tracked regions of various sizes in several observables to improve the signal-to-noise ratio. We then perform a ring-fit on the averaged power spectra to estimate the greatest depth into the convection zone that can be achieved using the current ring-analysis techniques.

Distribution of Area-Weighted Latitude of the Sunspots

Author(s): Heon-Young Chang
Affiliation(s): Kyoungpook National University/Stanford University

Monday May 2, 2011 Poster #15

We study the distribution of area-weighted latitude of the sunspots appearing from 1874 to 2009. The center-of-latitude (COL) is defined by averaging the latitude with the area. We form the latitudinal distribution of COL for the sunspots appearing in the northern and southern hemispheres separately, and in both hemispheres with unsigned and signed latitudes, respectively. We also compute three different statistical correlations between the cycle-integrated sunspot areas and the fitting parameters of all sunspot cycles from 1878 to 2009. Our findings related to the solar N-S asymmetry are as follows: (1) The distribution of COL is bimodal well represented by a double Gaussian function. (2) As far as the primary component of the double Gaussian function is concerned, for a given data subset, the distributions due to the sunspots appearing in two different hemispheres are alike. (3) When the northern (southern) hemisphere is dominant the width of the secondary component of the double Gaussian function in the northern (southern) hemisphere case is about twice as wide as that in the southern (northern) hemisphere. We also find, relating to the correlation between the cycle-integrated sunspot areas and the fitting parameters, that (1) Ignoring cycle 19, the characteristic width of the distribution of COL shows a significant correlation with the cycle amplitude. (2) A correlation between the location of the maxima of the COL distribution (either centroid_1 or centroid_2) and the sum of sunspot area can be found, when the data point corresponding to the solar cycle 19 is omitted.

Dependence of GCR influx rate on the solar North-South asymmetry

Author(s): Heon-Young Chang
Affiliation(s): Kyoungpook National University/Stanford University

Monday May 2, 2011 Poster #14

We investigate the dependence of the amount of the observed galactic cosmic ray (GCR) influx on the solar North- South asymmetry using the neutron count rates obtained from four stations and sunspot data in archives spanning five solar cycles from 1953 to 2008. We find that

the observed GCR influxes at Moscow, Kiel, Climax and Huancayo stations are more suppressed when the solar activity in the southern hemisphere is dominant compared with when the solar activity in the northern hemisphere is dominant. Its reduction rates at four stations are all larger than those of the suppression due to other factors including the solar polarity effect on the GCR influx. We perform the student's t-test to see how significant these suppressions are. It is found that suppressions due to the solar North-South asymmetry as well as the solar polarity are significant and yet the suppressions associated with the former are larger and more significant. Finally, we discuss its implications on the level of the temperature anomaly (TA). The observed GCR influx is more suppressed when the solar southern hemisphere is more active. When the GCR influx is reduced the cloud coverage can become low, leading to a lower albedo. Once the albedo changes the heat content at the surface of the Earth may be higher than that deduced by a model considering only the measured TSI leading to a higher TA.

Observing Flux Rope Formation During the Impulsive Phase of a Solar Eruption

Author(s): Xin Cheng
Affiliation(s): George Mason University

Wednesday May 4, 2011 Poster #82

Magnetic flux rope is believed to be an important structural component of coronal mass ejections (CMEs). While there exist much observational evidence of the flux rope post the eruption, e.g., as seen in remote-sensing coronagraph images or in-situ solar wind data, the direct observation of flux ropes during CME impulsive phase has been rare or non-exist. In this Letter, we present an unambiguous observation of a flux rope still in the formation phase in the low corona. The CME of interest occurred above the east limb on 2010 November 03 with footpoints partially blocked. The flux rope was seen as a blob of hot plasma in AIA 131 Å passband (peak temperature ~11 MK) rising from the core of the source active region, rapidly moving outward and stretching upward the surrounding background magnetic field. The stretched magnetic field seemed to curve-in, similar to the classical magnetic reconnection scenario in eruptive flares. The flux rope was also seen as a dark cavity in AIA 211 Å passpand (2.0 MK) and 171 Å passband (0.6 MK); in these relatively cool temperature bands, a bright rim clearly enclosed the dark cavity. The bright rim likely represents the pile-up of the surrounding coronal plasma compressed by the expanding flux rope. The composite structure seen in AIA multiple temperature bands is very similar to that in the corresponding coronagraph images, which consists of a bright leading edge and a dark cavity, commonly believed to be a flux rope.

Data-Driven Modeling of AR 11158

Author(s): Mark Cheung and Marc DeRosa
Affiliation(s): Lockheed Martin Solar & Astrophysics Laboratory

Tuesday May 3, 2011 1:44-2:02pm

We present results from numerical simulations of coronal field evolution in response to photospheric driving. In the simulations, the coronal field evolves according to magnetofriction, which ensures that the model field evolves toward a non-linear force-free state. Unlike static field extrapolation methods, this approach takes into account the history of the photospheric field evolution. This allows for the formation of flux ropes as well as current sheets between magnetic domains of connectivity. Using time sequences of HMI magnetograms as the bottom boundary condition, we apply this method to model the emergence and evolution of AR11158. In the simulation, the cancellation of magnetic flux within the active region leads to the formation and subsequent ejection of a flux rope. Comparisons of the model with AIA observations will be discussed.

Measurements of Solar Acoustic Waves Scattered by Sunspots with HMI Data

Author(s): Dean-Yi Chou
Affiliation(s): National Tsing Hua University, Taiwan

Tuesday May 3, 2011 Poster #43

The solar acoustic waves are scattered by sunspots because of the interaction between the acoustic waves and sunspots. We use a deconvolution method to obtain the 2-dimensional wavefunction of the scattered waves from the cross-correlation functions between the incident wave and the signals at other points on the surface. A time series of 13,583 frames for NOAA 11092 taken with HMI is used in this study. The scattered waves are predominant in the forward direction of the incident wave. The phase and amplitude of the scattered waves are different from those of the incident waves. The scattered waves can be used to probe the interaction between the acoustic waves and the sunspot.

Could Torsional Oscillations Excite Rossby Waves in the Photosphere Over a Sunspot? A (Simplistic?) Toy Model…

Author(s): Sebastien Couvidat
Affiliation(s): HEPL, Stanford University

Tuesday May 3, 2011 Poster #48

We study whether Rossby waves are excited in the solar photosphere when a large-scale zonal flow, the torsional oscillations, crosses the atmosphere over a sunspot, due to the change in vertical stratification produced by this sunspot. We surmise that this change in stratification modifies the absolute vorticity of a fluid parcel advected by the flow,

resulting in Rossby waves being forced. Following Spruit (2003), we assume that the solar torsional oscillations are in geostrophic balance. Following Lou (2000) we solve the equations of motion in the shallow-water approximation for the thin photospheric layer. As a first approximation, we neglect dynamical effects like flows in sunspots, except for turbulent motions that are included in a kinematic-viscosity parameter, and we also neglect magnetic-field effects other than on the stratification. These strong approximations allow the use of the quasi-geostrophic potential-vorticity equation with damping and forcing terms. Based on this equation we show the existence of a forced response to the interaction of torsional oscillations with a sunspot. Orders of magnitude for the fundamental properties of this response are presented.

HMI Wavelength Dependence From On-Orbit Calibration

Author(s): Sebastien Couvidat, Jesper Schou, Rock I. Bush, and Philip H. Scherrer

Affiliation(s): HEPL, Stanford University

Wednesday May 4, 2011 Poster #124

The Helioseismic and Magnetic Imager (HMI) instrument (Scherrer *et al*., 2011) on board the SDO satellite was thoroughly calibrated on the ground (Schou *et al*., 2011) to determine its wavelength dependence (Couvidat *et al*., 2011). An accurate knowledge of the 6 filter transmission profiles is a prerequisite to calculate meaningful observables (line-of-sight Dopplergrams, magnetograms, continuum intensities, and Stokes vectors). Since the launch of SDO, calibration sequences have been taken on orbit on a regular basis. These sequences allow, among others, a better determination of the full spectral ranges of the HMI optical-filter elements, to monitor the wavelength drift of the Michelson interferometers, to monitor the change in the interference pattern created by the front window, and to improve our estimate of the 6 filter transmission profiles. In this poster we present some of these results and compare the filter transmission profiles currently used in the observables code to the ones determined from ground calibration sequences and introduced in Couvidat *et al*. (2011).

Interacting Active Regions and Coronal Holes: Implications for Coronal Outflows and Solar Wind Structure

Author(s): J.L. Culhane(1), L. van Driel-Gesztelyi(1, 2, 3), D. Baker(1), A. Rouillard(4), A. Opitz(5)

Affiliation(s): (1) MSSL/UCL, Surrey, UK; (2) Obs. de Paris, France; (3) Konkoly Obs., Budapest, Hungary; (4) NRL, Washington DC, USA; (5) CNRS, Toulouse, France

Tuesday May 3, 2011 Poster #37

When active regions are adjacent to coronal holes, a variety of magnetic field interactions can result. These may include the interchange reconnection between the closed active region fields and the open field of the coronal hole, leading to fast and significant evolution of coronal hole boundaries. Outcomes may include variability of - or changes in, active region-associated hot plasma outflows and the modulation of the solar wind flows on open field lines. Depending on their relative positions on the Sun, the active region – coronal hole interactions may have their signatures embedded in co-rotating interaction regions or rarefaction regions. During the interval 2nd to 18th January, 2008 we have observed with Hinode a pair of coronal holes on the Sun, of opposite magnetic polarity and with two active regions between them. The latter are separated by the Heliospheric current sheet. This configuration has allowed us to address the coronal and solar wind outcomes and features mentioned above. The Hinode EIS instrument is used to locate active region-related outflows and measure their velocities. SOHO EIT imaging is used to follow the longer-term evolution of the coronal hole boundaries while MDI is used to observe changes in the magnetic field. STEREO imaging and in-situ data are also employed – as are ACE in-situ observations, to assess the resulting impacts on the interplanetary solar wind structures. The contrasting behaviour that results from magnetic interactions in this coronal hole/ active region configuration is described and assessed.

The UCLan SDO Data Hub

Author(s): S. Dalla, D. S. Brown, S. Chapman, M. Marsh, S. Regnier, R. W. Walsh

Affiliation(s): University of Central Lancashire

Wednesday May 4, 2011 Poster #112

A data pipeline for the distribution of SDO data products has been developed throughout a number of countries in the US, Europe and Asia. The UK node within this pipeline is at the University of Central Lancashire (UCLan), where a data center has been established to host a rolling SDO/AIA and SDO/HMI archive, aimed at supplying SDO data to the large UK solar scientific community. This presentation will describe the hardware and software structures of the archive, with focus on the ways in which scientists can retrieve data. Usage statistics and download speeds for the UCLan hub will also be presented.

SDO Data Distribution and Access

Author(s): Alisdair Davey and the VSO Team

Affiliation(s): Harvard Smithsonian Center for Astrophysics

Wednesday May 4, 2011 Poster #114

We describe the methods we have implemented to distribute SDO data within the US and Europe. This has put the data much closer to the various solar communities and eased access bottlenecks. We show the various ways by which the community can access and download SDO data easily via the VSO web and IDL interfaces. We provide an updated cheat-sheet for the community.

An Update on the SDO Feature Finding Team Efforts

Author(s): Alisdair Davey and the SDO Feature Finding Team

Affiliation(s): Harvard Smithsonian Center for Astrophysics

Wednesday May 4, 2011 Poster #113

We present an update on the efforts of the SDO Feature Finding Team. We have a number of modules now running in the Event Detection System (EDS) at LMSAL. We report on the state of the these modules and on the progress in implementing other modules. We describe some of the problems and lessons learned as we have progressed. Some of the modules are described in detail at this meeting, including the Flare Detective, Magnetic Feature Tracking, Polarity Inversion Line Properties and Image Segmentation.

The Role of the Chromosphere in Filling the Corona with Hot Plasma

Author(s): B. De Pontieu(1), S. McIntosh(2), M. Carlsson(3), V. Hansteen(3,1), T. Tarbell(1), P. Boerner(1), J. Martínez-Sykora(1,3), C. Schrijver(1), A. Title(1)

Affiliation(s): (1) Lockheed Martin Solar & Astrophysics Lab; (2) High Altitude Observatory; (3) University of Oslo

Tuesday May 3, 2011 4:54-5:12pm

We use coordinated observations from the Solar Dynamics Observatory (SDO), Hinode and the Swedish Solar Telescope (SST) to show how plasma is heated to coronal temperatures from its source in the lower atmosphere (or chromosphere). Our observations reveal a ubiquitous mass supply for the solar corona in which chromospheric plasma is accelerated upward into the corona with much of the plasma heated to transition region temperatures, and a small, but significant fraction heated to temperatures in excess of 1 million K. Our observations show, for the first time, how chromospheric spicules, fountain-like jets that have long been considered potential candidates for coronal heating, are directly associated with heating of plasma to coronal temperatures. These results provide strong physical constraints on the mechanism(s) responsible for coronal heating and do not seem compatible with current models. The association with chromospheric spicules highlights the importance of the interface region between the photosphere and corona to gain a full understanding of the coronal heating problem.

NLFFF Models of Active Regions

Author(s): Edward DeLuca, Antonia Savcheva, Aad van Ballegooijen

Affiliation(s): Harvard-Smithsonian Center for Astrophysics

Tuesday May 3, 2011 11:12-11:30am

We will present systematic comparisons of NLFFF models with coronal observations and MHD simulations. We can follow the evolution of the AR magnetic field through a sequence of static models. The field evolution that is observed is compared with the ideal evolution seen in 3D MHD models.

HMI signatures of White Light Flares

Author(s): P.Desai, R. Bogart, S. Couvidat, J. Schou

Affiliation(s): Stanford University

Wednesday May 4, 2011 Poster #87

Recent detections of white light continuum emission of solar flares with TRACE (Hudson et.al, 2006; Fletcher et.al,2007) and HINODE (Wang, H., 2009) have attracted a renewed interest in White-Light Flares (WLFs). The Helioseismic and Magnetic Imager (HMI) on the Solar Dynamic Observatory (SDO) produces a nearly continuous stream of full disc images of the sun in a set of six narrow wavelength bands around the FeI photospheric absorption line at 6173 Angstrom with filtergrams made at a cadence of one every 1.85 seconds. Preliminary analysis shows that the photospheric signature of Xray flares of sufficient intensity (Martinez Oliveros, J.C. *et al*, 2011) can be readily detected in the HMI data. Motivated by this finding, we have analyzed the HMI observables (in particular the Line Depth and Continuum Intensity) corresponding to some of the recent GOES M and X class flares (e.g. M6.6 on 2/13/2011, X2.2 on 2/15/2011). We discuss the implications of these results for the detection and analysis of white-light flares by HMI.

First Detection of Global Five-Minute Solar Oscillations in the Lower Corona Associated with Acoustic p-Modes Using SDO/EVE/ESP

Author(s): Leonid Didkovsky(1), Darrell Judge(1), Alexander Kosovichev(2), Seth Wieman(1), Tom Woods(3)

Affiliation(s): (1) University of Southern California, SSC; (2) Stanford University, HEPL; (3) Colorado University, LASP

Tuesday May 3, 2011 Poster #55

We report on the detection of oscillations in the lower corona in the frequency range of five-minute acoustic modes of the Sun. The oscillations have been observed using soft X-ray measurements from the Extreme Ultraviolet Spectrophotometer (ESP) of the Extreme Ultraviolet Variability Experiment (EVE) onboard the Solar Dynamics Observatory (SDO). The ESP zeroth-order channel observes the Sun as a star, without spatial resolution, in the wavelength range of 0.1 to 7.0 nm (the energy range is 0.18 to 12.4 keV). The spectrum of the oscillations calculated from six day time series shows a significant increase in the frequency range of 2 to 4 mHz. We interpret this increase as a response of the corona to solar acoustic (p) modes, and attempt to identify p-mode frequencies among the strongest peaks. This study shows that five-minute oscillations of the Sun can be observed in the lower corona in variations of the

soft X-ray emission. Further investigations of these oscillations will improve our understanding of the physics of the interaction of the oscillation modes with the solar atmosphere, and the interior-corona coupling.

Spectral Irradiance Oscillations Detected by the EVE/ESP and EVE/MEGS Channels during the X2.2 Solar Flare of February 15, 2011

Author(s): Leonid Didkovsky(1), Darrell Judge(1), Alexander Kosovichev(2), Seth Wieman(1), and Tom Woods(3)

Affiliation(s): (1) University of Southern California, SSC; (2) Stanford University, HEPL; (3) Colorado University, LASP

Wednesday May 4, 2011 Poster #91

The goal of this work is to study EVE/ESP and EVE/MEGS-A EUV irradiance measurements for detection of solar flare-related short-time variations in different spectral channels. We use three MEGS-A spectral lines, 30.38 (He II), 27.54 (Si VII), and 19.51 (Fe XII) nm, which are within the ESP spectral bands centered at 30, 26, and 18 nm correspondingly, to investigate variations of the EUV irradiance during the X2.2 solar flare of February 15, 2011. Both the ESP and MEGS-A wavelet spectra for each of these three pairs of spectral regions show increased short-period (100-300 sec) variations during and after the impulsive phase of the flare. The variations are of the oscillatory type and probably are caused by oscillations of the solar atmosphere and magnetic structures, excited by the flare. These flare-related variations of the spectral irradiance offer new perspectives for the investigation of energy release and transport in solar flares.

NASA Family Science Night: Changing Perceptions One Family at a Time

Author(s): Emilie Drobnes-Etesi(1), Dean Pesnell(2) , Martha Wawro(1), Kevin Addison(1), Sara E. Mitchell(3), Jake Noel-Storr(4), AleyaVan Doren(1)

Affiliation(s): (1) Adnet Systems, Inc; (2) NASA/GSFC; (3) Syneren; (4) Rochester Institute of Technology Center for Imaging Science Insight Lab

Tuesday May 3, 2011 Poster #71

The Family Science Night program invites middle school children and their families to explore the importance of science and technology in our daily lives by providing a venue for families to comfortably engage in learning activities that change their perception and understanding of science – making it more practical and approachable for participants of all ages. Unlike most youth science programs, this is an event where the entire family must participate together in all activities. Through this extensive and prolonged interaction, Family Science Night strives to change the way that children and their families participate in science, both within the program and beyond.

SDO E/PO: The Next Generation

Author(s): Emilie Drobnes-Etesi(1), Kevin Addison(1), Romeo Durscher(2), Steele Hill(3), David E. McKenzie(4), Dawn Myers(1), Emily Morton(5), Deborah Scherrer(2)

Affiliation(s): (1) Adnet Systems, Inc.; (2) Stanford Solar Center; (3) Wyle; (4) Montana State University; (5) CIRES Education and Outreach Program, University of Colorado

Monday May 2, 2011 5:10-5:28pm

With SDO successfully launched and beaming large amounts of data back to the ground, the SDO E/PO team has focused its efforts on finding solutions that put SDO data into the hands of the public. The question is how best to do this and what the portfolio of programs should look like. After briefly summarizing the highlights of our pre-launch activities, we will reintroduce the new and expanded SDO E/PO team, describe current efforts aimed at increasing the number of people exposed to SDO data, and start a dialog around how we as a community would like to move forward.

NASA Little SDO Social Media - An Engaging and Interactive Experience

Author(s): Romeo Durscher(1), Martha Wawro(2)

Affiliation(s): (1)Stanford University; (2) NASA GSFC

Tuesday May 3, 2011 Poster #70

The world of social media has become an important outlet of information and news around the world. Social networking now accounts for over 22% of all time spent online in the US. NASA puts strong emphasis on its social media programs, and, in fact, is the top-ranked social media user in the public sector. We will describe our SDO Social Media project, which aims to engage the public in learning about the SDO mission, the Sun, space weather, and the impact the Sun has on Earth and other NASA exploration missions. We'll discuss the various social media outlets and the techniques we use for reaching and engaging our audience. Effectiveness is measured through the use of various automatically-gathered statistics and level of public engagement. Of key importance to effective social media use is having access to scientists who can quickly respond to questions and express their answers in meaningful ways to the public. Our presentation will highlight the importance of scientist involvement and suggest ways for encouraging more scientists to support these efforts. It will also address how our social media approach has been paving the way for other Mission E/PO teams in using our best practices and experiences.

Time-Distance Analysis of Deep Solar Convection

Author(s): T. L. Duvall Jr.(1) and S.M. Hanasoge(2)

Affiliation(s): (1) NASA/GSFC; (2) Princeton Univ.

Monday May 2, 2011 Poster #28

Recently it was shown by Hanasoge, Duvall, and DeRosa (2010) that observational upper bounds on convective-flow velocities at spherical harmonic degrees $l<50$ are considerably smaller than magnitudes predicted by ASH simulations (Miesch *et al*. 2008) at r/R=0.95. The deep-focusing time-distance technique used to develop this upper limit was applied to simulations of linear acoustic wave propagation in a solar-like stratified sphere, perturbed by convective flows in order to calibrate the technique. This technique has now been applied to other depths in the convection zone and results will be presented. The deep-focusing technique has considerable sensitivity to flow signals at the desired subsurface location. However, as shown by Birch, there is much sensitivity also to near-surface signals. Modifications to the technique using multiple bounce signals have been examined in a search for more refined sensitivity (kernel) function. Initial results are encouraging and related results will be presented.

Developments in our Understanding of Energy Release and Transport in Solar Flares

Author(s): Gordon Emslie

Affiliation(s): Western Kentucky University

Thursday May 5, 2011 8:30-9:00am

Driven by data of unprecedented quality that spans an ever-increasing spectrum of observational manifestations, our picture of the response of the solar atmosphere to energy release and transport in solar active regions, particularly in solar flares, has dramatically increased in recent years. Concomitantly, modeling of energy release and transport has evolved significantly from the early steady-state, plane-parallel atmosphere approaches. Data are now sufficiently comprehensive that the relative energy content of various components of the energy release (e.g., nonthermal particles, thermal plasma, coronal mass ejection) can be assimilated in order to arrive at a quite comprehensive picture of the distribution of released energy. We can now accurately model the dynamic structure of flaring loops, and derive "loop scaling laws" that transcend the previous generation of static scaling laws. Imaging spectroscopy in hard X-rays has allowed us to determine the characteristics of the particle acceleration region independently of those of the propagation region ("target"), thus allowing us to significantly constrain particle acceleration models. I will review these developments and the prospects for further advancing our understanding of energy release processes in the active Sun.

Polarity Inversion Line Properties

Author(s): Alexander Engell

Affiliation(s): SAO

Wednesday May 4, 2011 Poster #96

I present an algorithm that determines the locations of polarity inversion lines for the areas of high magnetic flux as well as the quiet Sun. Within ARs values of magnetic gradient, transverse magnetic field strength and its direction (from potential field extrapolations) are determined along the PILs. These values will be used in statistical studies of solar eruptions such as Falconer *et al*. 2011. I specifically present on the X-class flare produced by AR 11158.

SDO-EVE Observations of EUV Dimming During Solar Flares

Author(s): F.G. Eparvier, R.A. Hock, T.N. Woods

Affiliation(s): Univ. Colorado - LASP

Wednesday May 4, 2011 Poster #93

The Multiple Extreme ultraviolet (EUV) Grating Spectrographs (MEGS) on the EUV Variability Experiment (EVE) on the NASA Solar Dynamics Observatory (SDO) measure the solar spectral irradiance from 6 to 105 nm at a spectral resolution of 0.1 nm and a time cadence of 10-seconds. MEGS captures emission lines from a broad range of temperatures in the solar atmosphere. Rather than increasing during some solar flares, certain lines such as FeIX (17.1 nm), decrease due to the ejection of material. The dimming behavior during these type of flares will be described and the use of EVE spectral irradiance measurements as diagnostics of Coronal Mass Ejections (CMEs) will be explored.

Probing Subsurface Flows Around Sunspots with 3-Dimensional Ring Inversions

Author(s): Nicholas A. Featherstone(1), Bradley W. Hindman(2), Michael J. Thompson(1) and Juri Toomre(2)

Affiliation(s): (1) High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO; (2) University of Colorado, Boulder, CO

Monday May 2, 2011 11:30-11:48am

We examine convective flows around sunspots as inferred through ring-analysis helioseismology of MDI Dopplergrams. These flow measurements were obtained using a novel 3-D inversion procedure termed ``Adaptively Resolved Ring-Diagram Inversions," or ARRDI, which uses sensitivity kernels based on the Born approximation. The ARRDI algorithm is multi-scale in nature, folding together information from tiles located at different positions on the solar surface and from tiles of different sizes, thus enabling fine control of the horizontal resolution and the probing depth. When we apply ARRDI to sunspots, we measure outflows persisting to depths of at least 7 Mm. In many instances, the surface outflow diminishes within the upper 3 Mm of the convection zone. Beyond 3 Mm, such outflows strengthen and attain peak amplitudes of ~200 m/s at depths of 5-7 Mm. We discuss the implications of such a two-component outflow for understanding the magneto-hydrodynamic behavior and evolution of sunspots.

Can we Determine Electric Fields and Poynting Fluxes from Vector Magnetograms and Doppler Measurements?

Author(s): George H. Fisher, Brian T. Welsch, William P. Abbett

Affiliation(s): SSL, UC Berkeley

Wednesday May 4, 2011 Poster #104

The availability of vector magnetogram sequences with sufficient accuracy and cadence to estimate the time derivative of the magnetic field allows us to use Faraday's law to find an approximate solution for the electric field in the photosphere, using a Poloidal-Toroidal Decomposition (PTD) of the magnetic field and its partial time derivative. Without additional information, however, the electric field found from this technique is under-determined -- Faraday's law provides no information about the electric field that can be derived the gradient of a scalar potential. Here, we show how additional information in the form of line-of-sight Doppler flow measurements, and motions transverse to the line-of-sight determined with ad-hoc methods such as local correlation tracking, can be combined with the PTD solutions to provide much more accurate solutions for the solar electric field, and therefore the Poynting flux of electromagnetic energy in the solar photosphere. Reliable, accurate maps of the Poynting flux are essential for quantitative studies of the buildup of magnetic energy before flares and coronal mass ejections.

On the Formation Height of the SDO/HMI Fe 6173Å DopplerSsignal

Author(s): B. Fleck(1), S. Couvidat(2), T. Straus(3)

Affiliation(s): (1) ESA; (2) Stanford Univ; (3) INAF/OAC

Wednesday May 4, 2011 Poster #125

The Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO) is designed to study oscillations and the magnetic field in the solar photosphere. It observes the full solar disk in the Fe I absorption line at 6173Å. We use the output of a high-resolution 3D, time-dependent, radiation-hydro-dynamical simulation based on the CO5BOLD code to calculate profiles $F(\lambda,x,y,t)$ for the Fe I 6173 Å line. The emerging profiles $F(\lambda,x,y,t)$ are multiplied by the HMI filter response functions $Ri(\lambda,1\leq i\leq 6)$ and filtergrams $Ii(x,y,t;\ 1\leq i\leq 6)$ are constructed for the 6 nominal HMI wavelengths. Doppler velocities $VHMI(x,y,t)$ are determined from these filtergrams using a simplified version of the HMI pipeline. The Doppler velocities are correlated with the original velocities in the simulated atmosphere. The cross-correlation peaks near 100 km, suggesting that the HMI Doppler velocity signal is formed rather low in the solar atmosphere. The same analysis is performed for the SOHO/MDI Ni I line at 6767 Å. We also study the impact of errors of the HMI calibration and how uncertainties in the HMI filter response function affects the calculated velocities.

Modeling EUV Solar Irradiance

Author(s): Juan Fontenla

Affiliation(s): LASP - University of Colorado

Thursday May 5, 2011 11:30-11:48am

The data streaming from SDO is being used for understanding the sources if the Solar Spectral irradiance at all wavelengths. The AIA images give the positions and features on the disk that are used for the modeling and the EVE measurements are used to compare the computed irradiance spectrum with the solar output. In the future vector magnetic fields will be used to gather the entire picture of how footpoints and loops relate both in structural and thermodynamic parameters. This provides important tools for modeling the past and near-future solar EUV output and for constraining the mechanisms of solar energy conversion in all plasma regimes.

First Results from Differential Emission Measure Tomography with AIA

Author(s): Richard A. Frazin, Alberto M. Vásquez, Enrico Landi, Paul Shearer

Affiliation(s): University of Michigan

Monday May 2, 2011 Poster #1

We present, for the first time, the results of 3D differential emission measure tomography (DEMT) applied to AIA data. The procedure has only be applied to STEREO=EUVI data previously (ApJ 701, 547). The tomographic reconstruction of 30.4 nm channel data provides a convenient tool for qualitative mapping of filaments, whereas combining the tomographic reconstructions from the bands dominated by coronal Fe lines yields a 3D determination of the electron density and temperature as well as higher order information. Compared to DEMT with EUVI, AIA provides enhanced temperature coverage and opportunity for testing assumptions used in the DEM inversion. Furthermore, we discuss the importance to stray light reduction and atomic physics uncertainties to DEMT science.

Coronal Prominence Cavities: Magnetism and Dynamics

Author(s): S. E. Gibson, G. de Toma, T. A. Kucera, D. Schmit, A. Sterling

Affiliation(s): NCAR/HAO

Wednesday May 4, 2011 Poster #101

Coronal mass ejections (CMEs) and associated prominence eruptions are spectacular manifestations of the Sun's magnetic energy. Elliptical regions of rarefied density, or cavities, are commonly observed surrounding coronal prominences, both quiescent and erupting. The prominence-cavity system is structured by magnetism, providing clues to to the processes that destabilize these equilibria and drive CMEs. The broad spectral coverage and high temporal

cadence of cavities and associated eruptions obtained by the Solar Dynamics Observatory Atmospheric Imaging Assembly (SDO/AIA) provide an important new window onto the magnetic structure of cavities, and onto their association with CMEs. We will present observations of cavities, both quiescent and erupting, and discuss how they constrain and motivate magnetic models of the prominence, cavity, and CME.

The Arka Mission

Author(s): L. Golub, E. Deluca and S. Kuzin
Affiliation(s): SAO and LPI

Monday May 2, 2011 Poster #17

The Arka mission is an Explorer-class Russian satellite experiment designed to study coronal dynamics with high resolution coronal EUV imaging and hard X-ray imaging spectroscopy and full Sun EUV context imaging. A proposal to NASA for an instrument to be included in Arka has been submitted as an MoO.

Meridional Circulation at High Latitudes

Author(s): I. Gonzalez Hernandez(1), R.S. Bogart(2), S. Chakraborty(2), R. Komm(1), C. S. Baldner(3), S. Basu(3), O. Burtseva(1), T. L. Duvall(4), D. A. Haber(5), F. Hill(1), R. Howe(6), K. Jain(1), M. C. Rabello-Soares(2) and S. Tripathy(1)
Affiliation(s): (1) National Solar Observatory; (2) Stanford University; (3) Yale University; (4) NASA/Goddard Space Flight Center; (5) University of Colorado; (6) Independent

Monday May 2, 2011 Poster #32

Meridional circulation has become a key ingredient in flux-transport solar-dynamo models. Long-term surface observations have revealed a pattern that varies throughout the solar cycle. The development of local-helioseismology methods, combined with medium-high continuous observations from the Global Oscillation Network Group (GONG) and the Michelson Doppler Imager (MDI) has allowed the monitoring of the meridional circulation below the solar surface during the last solar cycle. However, the inferences have been limited in latitude as well as in depth, due mainly to the uncertainties in the analysis methods and the resolution of the observation. New data coming from the Helioseismic and Magnetic Imager (HMI) instrument on board the Solar Dynamics Observatory (SDO) give us the unprecedented opportunity to extend the subsurface inferences of meridional circulation to higher latitudes. Here we show preliminary results obtained by using the ring-diagrams technique and review some of the systematics that need to be overcome to exploit the full potential of the observations.

Far-side Seismic Imaging with HMI

Author(s): I. Gonzalez Hernandez(1), R. S. Bogart (2), P. Scherrer(2), C. Lindsey(3), F. Hill(1), I. Suarez Sola(1) and A. Amezcua(2)
Affiliation(s): (1) National Solar Observatory; (2) Stanford University; (3) NorthWest Research Associates (CORA)

Wednesday May 4, 2011 Poster #134

Since the first images of active regions at the non-visible (or far-side) of the Sun appeared in 2000, the seismic holography technique has been used on a daily basis to calculate far-side maps using both Michelson Doppler Imager (MDI) and Global Oscillation Network Group (GONG) data. Recent improvements have turned the maps into a more useful tool for space weather forecasters. Soon after the launch of the Solar Dynamics Observatory, a preliminary pipeline was developed to calculate and provide continuous heliseismic far-side maps using the Helioseismic and Magnetic Imager (HMI) data. A tailored, optimized pipeline is being developed for HMI at the moment that will make use of the full potential of the data. In the mean time, the preliminary pipeline, run as a shared operation between Stanford and the National Solar Observatory (Tucson), is giving quite accurate results. Here we show the basic structure of this pipeline and the results.

Shock Formation Height in the Solar Corona Estimated from SDO and Radio Observations

Author(s): N. Gopalswamy(1) and N. Nitta (2)
Affiliation(s): (1) NASA Goddard Space Flight Center, (2) Lockheed Martin Solar & Astrophysics Laboratory

Monday May 2, 2011 4:36-4:52pm

Wave transients at EUV wavelengths and type II radio bursts are good indicators of shock formation in the solar corona. We use recent EUV wave observations from SDO and combine them with metric type II radio data to estimate the height in the corona where the shocks form. We compare the results with those obtained from other methods. We also estimate the shock formation heights independently using white-light observations of coronal mass ejections that ultimately drive the shocks.

SDO/AIA Observations of Flare Induced Oscillations of a Quiescent Prominence

Author(s): Sanjay Gosain
Affiliation(s): National Solar Observatory, Tucson, AZ

Wednesday May 4, 2011 Poster #110

We present the observations of flare induced oscillation in a quiescent prominence. The observations were obtained with an unprecedented spatial and temporal resolution by the Atmospheric Imaging Assembly (AIA) instrument onboard Solar Dynamics Observatory (SDO) mission. The full disk

filtergrams were obtained in EUV wavelengths with spatial resolution of 1.2 arc-sec and time cadence of 12 seconds. It is for the first time that we can observe the dynamics of the solar corona with such spatial and temporal coverage. Here we present the observations of an oscillating quiescent prominence which were induced by a nearby flare. The location of the flare and prominence were favorable for studying the whole body horizontal oscillations excited by a flare. The flare was accompanied by a CME event. The hydromagnetic disturbance produced during flare/CME, also called as EIT or EUV wave, reaches the prominence within about 300 seconds with an estimated speed of about 1300 km/s. On impact the prominence sheet starts to oscillate laterally as a whole with a period of about 30 minutes. These oscillations are damped within about 160 minutes i.e., within about six periods of oscillation. We apply the free oscillator model developed by Klezeck and Kuperus (1969) and deduce the magnetic field strength in the prominence to be of the order of 25 Gauss. Also, we estimate the kinetic energy gained by the filament to be of the order of 10^26 ergs. Further, we apply the local correlation technique (LCT) to derive the velocity of the oscillating structure locally. The top part of the prominence shows twice as large a velocity (~10 km/s) as compared to the lower part (~5 km/s).

The SDO Flare Detective

Author(s): Paolo Grigis
Affiliation(s): SAO

Thursday May 5, 2011 10:00-10:18am

We present the flare detective, a software module to automatically detect and characterize solar flares observed with the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO). Flares are detected in EUV images by analyzing lightcurves in macropixels and looking for times of strong increase in luminosity. We will report on the functionality and early performance of the flare detective. The events detected are made available to the Heliophysics Events Knowledgebase (HEK). This module is part of a larger effort to detect and track solar features and events that is optimized to run on the very large datasets provided by SDO.

Measurement of AIA point-spread function

Author(s): Paolo Grigis
Affiliation(s): SAO

Wednesday May 4, 2011 Poster #118

We present the results of the ongoing calibration work to measure the point-spread function (PSF) of the AIA telescopes on SDO. The PSF has a complex shape due to the presence of a double mesh that diffracts the incoming radiation and is visible as a characteristic octuple pattern during flares, as well as scattered light from the mirrors. The measurements of the strength of the wing of the PSF is very challenging due to its low intensity, and also due to the saturation of the central component of very bright sources like flare kernels. Measurements are performed during flares and eclipses of the Sun by the moon.

Constraining the Differential Emission Measure with Multi-Filter EUV Images

Author(s): C. Guennou(1), F. Auchère(1), K. Bocchialini(1), S. Parenti(2), N. Barbey(3)
Affiliation(s): (1) Institut d'Astrophysique Spatiale, Orsay, France; (2) Royal Observatory of Belgium, Brussels, Belgium; (3) SAp/Irfu/DSM/CEA, Saclay, France

Monday May 2, 2011 1:08-1:26pm

Estimates of coronal temperatures distributions have a key role in understanding many of the physical processes taking place into the Solar corona. For example, the distribution of temperature along loops or the (non)-isothermality of loops, impose constraints on the proposed heating mechanisms. Temperatures or DEMs are derived by inverting spectral data, which requires a carefully analysis of the nature of the solution especially in the case of broadband instruments. Indeed, results depend strongly upon the shape of the instrumental response curves, photon shot noise and systematic errors in the theoretical calculations of intensities. In this work, we present a comprehensive study of this ill posed inverse problem, using Monte Carlo simulations of observed intensities in the six coronal temperature filters of the Atmospheric Imaging Assembly (AIA) instrument on board the Solar Dynamics observatory (SDO). We have taken into account observations biases, such as shot noise, read noise, and uncertainties on the AIA calibration and on the atomic data. We performed various isothermal and multithermal simulations to constrain simple DEM models and to determine if the AIA data are sufficient to distinguish isothermal from multithermal plasma.

Solar Rotational Tomography with SDO/AIA Data

Author(s): C. Guennou(1), F. Auchère(1), K. Bocchialini(1), N. Barbey(2)
Affiliation(s): (1) Institut d'Astrophysique Spatiale, Orsay, France; (2) SAp/Irfu/DSM/CEA, Saclay, France

Tuesday May 3, 2011 Poster #59

Tomographic imaging is a powerful method that allow us to determine the three dimensional structure of the solar corona. This is a very helpful tool to understand and study the morphology of structures such as polar plumes and to derive their physical properties. We performed static tomographic inversions of SDO/AIA data from december, 2010 using the TomograPy python package (Barbey *et al.*, submitted). We used the six coronal temperatures bands of SDO/AIA and time series of 28 days. We present 3-D maps of electron densities and temperatures obtained using the isothermal assumption.

A "Living With a Star" Is Born

Author(s): Madhulika Guhathakurta

Affiliation(s): NASA Headquarters

Monday May 2, 2011 8:30-9:00am

NASA's Living With a Star program was inevitable. Its genesis was foretold in the ancient Indian epic Mahabharata. In this talk, Lika Guhathakurta decodes the sanskrit to reveal the past--and what the future holds for LWS.

Study of Differences Between Sunspot and White Light Facular Area Data Determined from SDO and SOHO Observations

Author(s): L. Gyori

Affiliation(s): Debrecen Heliophysical Observatory, Gyula Observing Station, 5701 Gyula, P.O.Box 93, Hungary

Monday May 2, 2011 Poster #12

Sunspot and white light facular areas are important data of the solar activity and are used, for example, in study of evolution of sunspots and their effect on solar irradiance. The SDO solar images have mutch higher resolution (~0.5"/pix) than the SOHO solar images (~2"/pix). This difference in image resolution has a significant impact on the sunspot and white light facular areas measured in the two imageries. Here we compare the area of sunspots and white light faculae derived from the SDO and the SOHO images. This comparison helps the calibration of the SOHO sunspot and facular area to the SDO.

Subsurface Flows Near a New Solar Cycle Filament

Author(s): Deborah A. Haber(1), Richard S. Bogart(1) and Nicholas Featherstone(3)

Affiliation(s): (1) JILA / Univ. of Colorado; (2) HEPL Stanford University; (3) High Altitude Observatory

Wednesday May 4, 2011 Poster #107

HMI has observed a number of very long filaments on the Sun during this new solar cycle. Several erupted in spectacular fashion, generating large CMEs. One explanation for the cause of a CME is that the magnetic field, supporting relatively cool filament gas, becomes twisted up by the turbulent convective flows near the footpoints of the filament. This causes an instability which leads to a reconnection event, releasing significant amounts of energy toward the expulsion of the gas away from the Sun in a CME. Determining the subsurface flows in the Sun's near surface shear layer capable of moving the magnetic field is thus important information for theories of coronal mass ejections from otherwise quiescent filaments. We present here preliminary measurements of the horizontal subsurface flows near the neutral line of an extended filament using the local helioseismic technique of ring analysis along with a new 3-D inversion code. The inversion code combines information from 2, 4, and 16 degree tiles in order to find self-consistent flows which preserve the high spatial resolution information provided by the small tiles with the greater depth information available through analysis of the large tiles. The velocity data used in this analysis were obtained with the HMI instrument aboard SDO.

Adjoint Methods for Local Helioseismology

Author(s): S.M. Hanasoge(1,2), A.C. Birch(3), L. Gizon(1), J. Tromp(2,4)

Affiliation(s): (1) Max-Planck-Institut fur Sonnensystemforschung; (2) Department of Geosciences, Princeton University; (3) NWRA, CoRA Division; (4) Program in Applied & Computational Mathematics, Princeton University

Wednesday May 4, 2011 Poster #135

For a given misfit function - a specified optimality measure of a model - its gradient describes the manner in which one may alter properties of the model to march towards a stationary point. The adjoint method is a form of constrained partial-differential-equation optimization that describes a means of extracting derivatives of a misfit function with respect to model parameters through finite computation. It relies on the accurate calculation of a series of Green's functions for two types of sources, namely the convection spectrum, resulting in the forward wavefield, and differences between predictions and observations, resulting in an adjoint wavefield. All sensitivity kernels relevant to a given measurement emerge directly from the evaluation of an interaction integral involving these wavefields. The technique facilitates computation of sensitivity kernels for three-dimensional heterogeneous background models, thereby paving the way for non-linear iterative inversions. An algorithm to perform such inversions using as many observations as desired is discussed.

Meridional Flow Measurements Using Artificial Data from 3D Numerical Simulations of Wave Propagations in the Whole Sun

Author(s): Thomas Hartlep(1), Markus Roth(2), Hans-Peter Doerr(2), Alexander Kosovichev(1), Junwei Zhao(1)

Affiliation(s): (1) Hansen Experimental Physics Laboratory, Stanford University; (2) Kiepenheuer-Institut für Sonnenphysik, Freibug, Germany

Monday May 2, 2011 Poster #34

The structure of the meridional flow and in particular the depth of its return flow in the deep solar interior are of significant interest for understanding the solar dynamo and the variability of the Sun. Measuring such small flows in the deep interior is a challenging problem. Numerical simulations provide means for testing and calibrating measurement techniques to increase our confidence in the inferences obtained from observations. Here, we present results from analyzing artificial helioseismology data obtained from a numerical simulation of helioseismic wave

propagation in the whole 3D solar interior with an artificial model of a meridional circulation present in the background state. Two methods - a time-distance helioseismology technique and a Fourier-Legendre decomposition technique - are used in this paper to try to detect and measure this flow from the oscillations at the solar surface. Preliminary results are compared with the prescribed flow model.

Nearly Steady Flows from HMI

Author(s): David H. Hathaway
Affiliation(s): NASA Marshall

Monday May 2, 2011 Poster #26

The nearly steady flows observed at the photosphere have been defined as everything but the 5-minute p-mode oscillations. They include the axisymmetric flows – differential rotation and meridional circulation, and the non-axisymmetric cellular flows – granulation, supergranulation, and giant cells. The photospheric signatures of these flows can be found in the direct Doppler signal and by correlation tracking using velocity, intensity, and magnetic images. I have previously developed a suite of analysis programs for extracting these flows from SOHO/MDI data. These programs have been revised, updated, and augmented to accommodate SDO/HMI data. I will present results from the analysis of HMI data from a single Carrington rotation.

MHD Simulation of the Solar Corona in Early August Using the HMI Magnetic Field Data

Author(s): K. Hayashi, X.P. Zhao, Y. Liu, J.T. Hoeksema and X. Sun
Affiliation(s): Stanford University

Tuesday May 3, 2011 Poster #41

The HMI is observing the line-of-sight magnetic field, vector field and the LoS Doppler plasma motion. The full-disk magnetogram observation with high temporal and spatial resolution provides better global solar magnetic field map, in that the data gap is minimized and the noise level is quite low. Utilizing the benefit of the HMI's magnetogram observation, we will show the results of the MHD simulation of the solar corona, mainly focusing on the August 1st event, to see how the magnetic field connectivity in the global scale had changed around the period. We will use the synchronic frame format to make the global solar surface LoS magnetic field map so that the magnetic field distribution will be better represented at the time of interest. Also, as another test, we will use the daily-updated whole-sun magnetic field dataset in order to test the capability to reproduce the coronal variations on real-time basis.

Solar Polar Coronal Hole Areas Through the Past Solar Minimum

Author(s): Shea A. Hess Webber, Nishu Karna, W. Dean Pesnell, Michael Kirk
Affiliation(s): Catholic University

Monday May 2, 2011 Poster #18

We have used the perimeter tracking algorithm and analysis of EIT synoptic maps to extend our timeseries of polar coronal hole areas through solar minimum (through 2010). Both algorithms use 171, 195, and 304 Å images from the Extreme ultraviolet Imaging Telescope (EIT) on SOHO, the first to measure the perimeter of polar coronal holes as they appear on the limbs and the second the area of the polar coronal hole during each Carrington rotation. Line-of-sight magnetic field synoptic maps are also used to estimate the polar coronal hole area. We have updated the time series and we are analyzing uncertainties in EIT ephemeris data. We remain convinced that the northern polar hole area is measurably smaller in the recent minimum than it was at the beginning of cycle 23, while the southern polar hole area is roughly the same. Polar hole areas found via perimeter tracking agree within uncertainty with those determined using EIT synoptic map analysis.

What's Happening Inside the Sun?

Author(s): Bradley W. Hindman
Affiliation(s): JILA

Monday May 2, 2011 5:30-6:00pm

The enhanced resolution and continuous imaging made possible by HMI will lead to many contributions in our understanding of the Sun's subsurface flow fields. Here I will concentrate on two scientific problems for which HMI is posed to make imminent breakthroughs: the subsurface structure and evolution of sunspots and active regions and the detection of deep meridional circulations. I will concentrate on what we have already learned through helioseismic analyses and indicate where progress is likely to be made in the immediate future.

Solar Flare Classification Using SDO and the Impact on the EUV Irradiance

Author(s): Rachel A. Hock, Francis G. Eparvier, Thomas N. Woods, Andrew R. Jones
Affiliation(s): Laboratory for Atmospheric and Space Physics, University of Colorado Boulder

Wednesday May 4, 2011 10:36-10:54am

Since its launch on 11 February 2010, NASA's Solar Dynamic Observatory (SDO) has observed numerous flares. Between 1 May 2010 and 28 February 2011, Extreme ultraviolet Variability Experiment (EVE) captured over 200 C-class, 28 M-class, and 1 X-class flares. From these

observations, we have noticed that flares of similar GOES class can have significant differences in the amount and timing of the increase of EUV irradiance due to the flare. In this work, we classify flares based on the topology in AIA observations. Observed classes include compact flares, sigmoid flares, arcade flares, sigmoid-to-arcade flares, and late phase flares. A description, example and frequency of each of these classes are presented along with the implications for modeling the EUV irradiance of solar flares.

HMI Magnetic Field Data Products

Author(s): J. Todd Hoeksema and the HMI Magnetic Field Team

Affiliation(s): Stanford University

Wednesday May 4, 2011 Poster #126

The Helioseismic and Magnetic Imager (HMI) on NASA's Solar Dynamics Observatory (SDO) routinely produces a wide variety of magnetic field data products including 45-second line-of sight magnetograms, 12-minute vector field times series in HMI Active Region Patches (HARPs), synoptic maps and synchronic frames, model calculations of the coronal field and solar wind, and near-real-time parameters for space weather. Other products, such as surface flow maps, can be produced on demand or on request. We present examples of data products collected during the first year of operations and compare some of these with measurements from other observatories, including the now-dormant MDI.

Low-degree Helioseismology from the Solar Dynamics Observatory

Author(s): R. Howe(1), A.-M. Broomhall(2), W.J. Chaplin(2), Y. Elsworth (2), F. Hill (3), K. Jain (3), R. Komm (3)

Affiliation(s): (1) Independent; (2) University of Birmingham; (3) National Solar Observatory

Monday May 2, 2011 Poster #23

The AIA 1600 and 1700 Angstrom bands are formed in the upper photosphere and are sensitive to the five-minute oscillations used in helioseismology. We show some preliminary results from the analysis of Sun-as-a-Star time series derived from these data, together with velocity and continuum observations from HMI and velocity from the Birmingham Solar Oscillations network.

HMI Local Frequency Shifts from Ring Diagram Analysis

Author(s): R. Howe (1), R. Bogart (2), D. Haber (3), K. Jain (4) S. Tripathy (4), F. Hill (4), R. Komm (4)

Affiliation(s): (1) Independent; (2) Stanford University; (3) University of Colorado; (4) National Solar Observatory

Monday May 2, 2011 Poster #24

More than six full Carrington rotations have now been analyzed through the HMI ring-diagram pipeline. We present results showing the variation with disk position and magnetic activity index of the estimated frequency from two different fitting algorithms. The pattern of frequency variation with magnetic activity index is generally consistent with that seen in earlier work using MDI and GONG. For comparison, we include results from GONG observations in CR 2099.

Large-scale Zonal Flows During the Solar Minimum and the Rise of Cycle 24

Author(s): R. Howe(1), R. Komm(2), F. Hill(2), J. Christensen-Dalsgaard(3), T.P. Larson(4), J. Schou(4), M.J. Thompson(5)

Affiliation(s): (1) Independent; (2) National Solar Observatory; (3) Aarghus University; (4) Stanford University; (5) HAO/University of Sheffield

Monday May 2, 2011 Poster #25

The so-called torsional oscillation is a pattern of migrating zonal flow bands that move from mid-latitudes towards the equator and poles as the magnetic cycle progresses. Helioseismology allows us to probe these flows below the solar surface. The prolonged solar minimum following Cycle 23 was accompanied by a delay of 1.5 to 2 years in the migration of bands of faster rotation towards the equator. During the rising phase of Cycle 24, while the lower-level bands match those seen in the rising phase of Cycle 23, the rotation rate at middle and higher latitudes remains slower than it was at the corresponding phase in earlier cycles, perhaps reflecting the weakness of the polar fields. We will present the latest results based on nearly sixteen years of global helioseismic observations from GONG and MDI, with recent results from HMI, and discuss the implications for the development of Cycle 25.

Doppler Signatures in EVE Spectra, and Flares

Author(s): H. Hudson, T. Woods, P. Chamberlin, L. Fletcher, and D. Graham

Affiliation(s): SSL/UC Berkeley

Wednesday May 4, 2011 Poster #92

The Extreme-ultraviolet Variability Experiment (EVE) on SDO is providing a comprehensive set of EUV spectra of the Sun as a star. The routine sampling is with 10 s integrations at a resolution of 0.1 nm. Although this resolution corresponds to only some 1000 km/s in velocity space, we demonstrate that the instrument is stable enough to detect the SDO orbital motion of a few km/s readily in the bright He II line at 30.4 nm. We find the random error in the centroid location of this line to be less than one pm (less than 1 km/s) per 10 s integration. We also note systematic effects from a variety of causes. For flare observations, the line centroid

position depends on the flare position. We discuss the calibration of this effect and show that EVE can nonetheless provide clear Doppler signatures that may be interpreted in terms of flare dynamics. This information has some value in and of itself, because of EVE's sensitivity, but we feel that it will be of greatest importance when combined with imagery (e.g., via AIA) and modeling. We discuss flare signatures in several events, e.g. the gamma-ray flare SOL2010-06-12 and SOL2011-02-16T:07:44, taking advantage of AIA image comparisons. We also discuss the non-gamma-ray events SOL2011-02-15 and SOL2011-03-07T19:43 for comparison.

The HEK in Action

Author(s): Neal Hurlburt and the HEK Team
Affiliation(s): Lockheed Martin ATC

Wednesday May 4, 2011 Poster #116

The Heliophysics Events Knowledgebase (HEK) system is being developed to help solar and heliospheric researchers locate SDO data associated with solar features and events of interest to their science topics. After 9 months of operations using data from SDO we present an overview of the HEK system In action.

Nonlinear Three-dimensional Magnetoconvection Around Magnetic Flux Tubes

Author(s): N. Hurlburt(1), G. Botha(2) and A. Rucklidge(3)
Affiliation(s): (1) Lockheed Martin ATC; (2) Warwick University; (3) University of Leeds

Monday May 2, 2011 11:12-11:30am

We study the decay process of large magnetic flux tubes, such as sunspots, on a supergranular scale. 3D nonlinear resistive magnetohydrodynamic numerical simulations are performed in a cylindrical domain, initialized with axisymmetric solutions that consist of a well-defined central flux tube and an annular convection cell surrounding it. The decay of the tube is dependent on the convection around it: convection can remove flux from, add flux to, or change the shape of the central flux tube, depending on parameter values. Convection cells forming inside the flux tube as time-dependent outflows around the tube will remove magnetic flux. Flux is added to the tube when flux caught in the surrounding convection is pushed toward the tube. Our results suggest that it is only when convection inside the flux tube is sufficiently suppressed by the remaining magnetic field that the flux tube can persist, and all examples of persistent flux tubes had the same effective magnetic field strength. This is consistent with the observation that pores and sunspot umbrae all have roughly the same magnetic field strength.

Frequency Distribution of Photospheric Cancellation Events in Quiet Sun

Author(s): Y. Iida, H. Hagenaar, and T. Yokoyama
Affiliation(s): University of Tokyo

Tuesday May 3, 2011 Poster #54

We investigate a magnetic flux dependence of photospheric cancellation frequency by using magnetograms obtained in a long-term observational sequence by Hinode satellite. Parnell *et al*. (2009) reported a power-law distribution of magnetic flux content in the range covering from the small patches in quiet Sun to the large active region fluxes. This distribution is thought to be achieved and sustained by four magnetic activities: namely flux emergence, merging, splitting, and cancellation (Schrijver *et al*., 1997). However, there are a few reports about flux distributions of these activities. Flux dependences of merging and splitting are reported by the authors. It is shown that emergence and cancellation in target range do not have a significant effect on flux distribution maintenance because of their low occurrence rate. However, there is a possibility that emergence and cancellation of tiny patches below the detection threshold have a significant effect on the maintenance of a flux distribution.The importance of tiny cancellations below the threshold can be speculated by an investigation of flux dependence with an assumption that the dependence continues to below the threshold. The magnetograms obtained by Hinode/SOT from December 30th in 2008 to January 5th in 2009 is used in this study. Time interval between magnetograms is 5 minutes and field of view is 121"x121". The period of this data set is long enough for a statistical investigation of cancellations. 5973 cancellations are detected in this data set. Cancellation occurrence rate depends on flux content with a power-law index of -2.52. The slope steeper than -2 indicates that tiny cancellations take more important roles in the maintenance of flux distribution. Based on the observational results, we will propose a model explaining a relationship between the frequency distributions of the flux contents in magnetic patches and of the cancellation events.

Subsurface Signatures of Emerging Active Regions

Author(s): Stathis Ilonidis and Junwei Zhao
Affiliation(s): Stanford University

Tuesday May 3, 2011 Poster #57

Solar magnetic fields are generated by a dynamo action in the interior of the Sun and then emerge to the surface. The properties of flux emergence are related to some of the most important problems in solar physics: the depth of dynamo, the appearance and evolution of active regions, the formation of sunspots, the initiation of flares and coronal mass ejections, and the 11-year activity cycle. The goal of this study is to detect signatures of emerging magnetic flux in the solar interior before the flux becomes visible on the surface. We apply a new measurement scheme to continuous

Doppler observations by both SOHO/MDI and SDO/HMI. Our measurement scheme is applied only to quiet regions, before the emerging magnetic flux appears in these regions, in order to avoid surface magnetism effects. We discuss the results of our work and the impact on space weather forecast.

The Helioviewer Project or How to Let Everyone Easily Browse Petabytes of Solar and Heliospheric Data

Author(s): J. Ireland(1), V. K. Hughitt(1), D. Mueller(2), B. Fleck(2)

Affiliation(s): (1) ADNET Systems, Inc./NASA GSFC; (2) European Space Agency

Wednesday May 4, 2011 Poster #115

The Helioviewer Project gives users great flexibility in browsing solar and heliospheric data. Users can create their own images/movies by overlaying and manipulating images from multiple solar and heliospheric instruments and missions such as SDO (Solar Dynamics Observatory) and SOHO (Solar and Heliospheric Observatory). The user can interactively select the location in the sky, timescale, lengthscale and data type through our simple-to-use tools, www.helioviewer.org and JHelioviewer. Since their release, users of these tools are creating 15-20,000 movies every two weeks, suggesting that there is a strong desire in our user community to explore solar and heliospheric data for themselves, and to share what they find with others. We will begin by discussing the technological basis of the Helioviewer Project, describing how our approach solves the problem of browsing through petabytes of solar and heliospheric data, allowing the construction of a back-end infrastructure that is portable, easy to install, and expandable to include data from many more solar and heliospheric instruments. We will also discuss expansions of the Helioviewer Project, such as using Virtual Solar Observatory services, the AIA (Atmospheric Imaging Assembly) cutout service. Finally we will discuss the creation of a "citizen scientist" application to allow the public to contribute to the analysis of SDO data, and give some comments about what the public does with SDO and other image data available via the Helioviewer Project.

Helioseismic Analysis of Flaring Regions Using Multi-spectral Data from the SDO

Author(s): Kiran Jain(1), S. Tripathy(1), R. Bogart(2), C. S. Baldner(3), S. Basu(3), O. Burtseva(1), I. Gonzalez Hernandez(1), D. A. Haber, F. Hill(1), R. Howe(4), R. Komm(1) and M C. Rabello-Soares(2)

Affiliation(s): (1) National Solar Observatory, USA; (2) Stanford University, USA; (3) Yale University, USA; (4) Independent

Wednesday May 4, 2011 Poster #90

There has been some evidence that flares may excite p modes although the acoustic power is known to be suppressed in the regions of high magnetic field. We apply the technique of ring diagrams to study the mode characteristics of both flaring and non-flaring regions using multi-spectral data from the Helioseismic and Magnetic Imager (HMI) and Atmospheric Imaging Assembly (AIA) onboard Solar Dynamics Observatory (SDO). The 1600 and 1700 Angstrom continuum measurements from the AIA in conjuction with Fe I 6153 Angstrom Doppler and continuum intensity observations from the HMI provide a unique data base to investigate the sensitivity of inferences to the choice of observing height and observable, and to quantify differences. This will provide a new insight into the study of the interaction of p modes with the regions of high magnetic field.

Solar Atmospheric Seismology with HMI and AIA Onboard SDO

Author(s): Kiran Jain(1), S. Tripathy(1), S. Kholikov(1), I. Gonzalez Hernandez(1), F. Hill(1), J. Leibacher(1), R. Howe(2), F. Baudin(3), M. Carlsson(4), W. Chaplin(5), T. Tarbell(6)

Affiliation(s): (1) National Solar Observatory, USA; (2) Independent; (3) Institut d'Astrophysique Spatiale, France; (4) University of Oslo, Norway; (5) University of Birmingham, UK; (6) Lockheed Martin Solar and Astrophysics Laboratory, USA

Tuesday May 3, 2011 Poster #68

The successful launch of the Solar Dynamics Observatory (SDO) in February 2010 opens important, new possibilities for helioseismic exploration of the solar interior and atmosphere using multi-wavelength observations from multiple instruments. In order to better understand the solar interior and atmosphere, as well as the physics of the helioseismic modes and waves themselves, we exploit the potential of the Atmospheric Imaging Assembly (AIA) 1600 and 1700 Angstrom continuum measurements and the contemporaneous Helioseismic and Magnetic Imager (HMI) Fe I 6173.3 Angstrom velocity and intensity observations. Standard techniques of helioseimology e.g Sun-as-a-star, spherical harmonic analysis, ring diagrams, and time-distance analysis are applied to obtain acoustic mode parameters and other charateristics. Here we present our preliminary results, and interpret these in the context of the differences in the heights of formation of the lines.

What are the outstanding basic physical questions concerning the understanding of the Sun as a star?

Author(s): Moira Jardine
Affiliation(s): University of St Andrews

Thursday May 5, 2011 9:00-9:30am

Magnetic fields appear to be ubiquitous in almost all types of stars, but the nature of these fields and their role in influencing the structure and evolution of the star and its environment can vary significantly. Recent advances in

spectropolarimetry have revealed the diversity of stellar magnetic fields and have allowed us to place the Sun within the context of other stars. In this talk I will review these results and highlight the basic physical process that are often taken for granted on the Sun, but which show strikingly different behaviours on other stars.

Developing Near Real-time Space Weather Products with SDO EVE Data

Author(s): A. R. Jones, T.N. Woods, F. Eparvier, D. Woodraska, C. Jeppesen, R. Hock, L. Didkovsky, S. Wieman, J. Goetz

Affiliation(s): University of Colorado, LASP

Monday May 2, 2011 Poster #7

We will look at comparisons of the EVE ESP 0.1-7nm and the GOES XRS 0.1-0.8 nm channel.The ESP data is available near real-time, and uses a quadrant detector, so near real-time flare location estimates can be provided. The GOES-R series XRS will also have quadrant detectors, so this is prelude to what we can expect from future operational data.

Hot Flare Plasma Observed by Nobeyama Radioheliograph, RHESSI, and AIA/SDO

Author(s): Sujin Kim(1), Hazel Bain(2), Kiyoto Shibasaki(1)

Affiliation(s): (1) Nobeyama Solar Radio Observatory / National Astronomical Observatory of Japan; (2) Space Sciences Laboratory / University of California Berkeley

Monday May 2, 2011 Poster #19

We have investigated supra-arcade structure produced by M1.6 flare that occurs in east-north limb on 2010 Nov 4th. It is observed in microwave at 17 GHz with Nobeyama Radioheliograph (NoRH), Hard X-rays at the range of 8-20 keV with Ramaty High Energy Solar Spectroscopic Imager (RHESSI), and EUV with Atmospheric Imaging Assembly (AIA) onboard Solar Dynamic Observatory (SDO). As reported by Reeves & Golub (2011), the supra-arcade structure comes into sight predominantly on AIA 131 Å channel that contain a contribution from Fe XIX formed at 11 MK (Boerner *et al*. 2011). While this hot flare plasma lasts over the decay phase of the flare, it shows some interesting characteristics in microwave and hard X-rays as follows. In the hot flare plasma, 1) brightness temperature (TB) of microwave emission increase gradually up to 2x10^4 K, and 2) hard X-ray sources appear on the bright structures inside of the hot flare plasma as well as top of the post-flare arcade. We have derived the variation of emission measure, density, and energy of each hard X-ray source region using TB obtained by 17 GHz microwave observation. Based on the results, we discuss the physical mechanism to generate the hot flare plasma.

Role of Vortex Tube Dynamics in the Formation of Magnetic Structures and Acoustic Wave Excitation on the Sun

Author(s): I.N. Kitiashvili(1), A.G. Kosovichev(1), S.K. Lele(1), N.N. Mansour(2), J.O. Stenflo(3), A.A. Wray(2)

Affiliation(s): (1) Stanford University, USA; (2) NASA Ames Research Center, USA; (3) Swiss Federal Institute of Technology, Switzerland

Tuesday May 3, 2011 Poster #56

Turbulent behavior of solar magnetoconvection is a key to understanding the phenomena of multiscale convective and magnetic structurization, and acoustic emission in the quiet Sun and active regions. Recent radiative 3D MHD numerical simulations showed that many of these phenomena are related to the formation, dynamics and interaction of turbulent vortex tubes, which spontaneously appear in the intergranular lanes. The vortices are characterized by sharp decreases of density and temperature and high-speed swirling downflows. Their interaction may lead to formation of mesogranular-scale convection. In magnetic regions, the vortex tubes become the centers of magnetic bundling and spontaneous formation of stable pore-like magnetic structures. In this process, a strong vortex tube initializes the magnetic field accumulation by converging downflows and creating a local low-pressure region. In addition, the simulations reveal that the process of acoustic waves excitation is caused by interaction and partial annihilation of vortex tubes below the photosphere. The vortex tubes have been detected in high-resolution observations of the photosphere and chromosphere. To compare our results with observations, we calculate the full Stokes profiles for the spectral lines observed by the SDO/HMI and Hinode/SOT/FPP instruments, and simulate the instrumental resolutions. This provides observational characteristics for the vortex detection and detailed investigation of their properties.

The Impact of Nonequilibrium Ionization on SDO/AIA and Hinode/EIS Observations of Impulsively Heated Plasmas

Author(s): James A. Klimchuk(1), Stephen J. Bradshaw(2)

Affiliation(s): (1) NASA/GSFC; (2) Rice University

Tuesday May 3, 2011 4:36-4:54pm

Most plasma diagnostics assume the emitting material is in a state of ionization equilibrium. For example, the AIA temperature response functions have been derived on this basis. The assumption is reasonable whenever the plasma is evolving slowly or is very dense, but these are not the conditions that apply during impulsive heating events. It is now widely believed that many coronal loops are bundles of unresolved strands that are heated quasi-randomly by nanoflares. Full blown flares are thought to have similar sub-structure. We have studied the importance of nonequilibrium effects in these circumstances by modeling nanoflare-heated

loops and simulating their observation by AIA and the EIS spectrometer on Hinode. We find that the intensities of hot emission lines can be highly suppressed and that the net emission from the loop tends to be dominated by strands that have entered a slow cooling phase, well after the impulsive energy release has ended. The hottest strands are relatively invisible, both because they are tenuous and because they cool rapidly by thermal conduction. Thus, AIA channels that are normally thought of as being sensitive to hot plasma, such 131 and 94, are in fact frequently not able to detect the hot plasma that is present. The magnitude of the effect is case dependent. Great care must be exercised when using the standard temperature response functions in situations where nonequilibrium ionization is likely to be important.

The Space Public Outreach Team at Montana State University

Author(s): Adam Kobelski, David E. McKenzie
Affiliation(s): Montana State University

Tuesday May 3, 2011 Poster #72

The Space Public Outreach Team (SPOT) program at Montana State University brings presentations about current NASA missions, including SDO, to Montana K-12 students at no cost to the schools. This Education and Public Outreach model of undergraduate presenters, graduate student managers, and faculty advisers has been field tested in Montana for over thirteen years and is now exportable to other institutions. The SPOT program is a proven success, garnering rave reviews from students and teachers alike, while reaching tens of thousands of geographically isolated and underserved populations. We will outline the SPOT model and highlight some of the program's successes.

The Eruptive Prominence from 30 March 2010 as Observed with SDO/AIA

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Wednesday May 4, 2011 Poster #109

We analyzed the AIA/SDO 304 images of the 30 March 2010 eruptive prominence. We characterize the evolving structure by the altitude of the apex, the distance between the feet and the twist, all parameters determined in the plane of sky. We display their variations with time during the main two episodes of the eruption : slow and then fast rise (with acceleration). We discuss the results in the frame of the "magnetic flux rope (MFR)" model.

HMI Divergence and Vorticity Maps from Ring-diagram Analysis

Author(s): R. Komm(1), R.S. Bogart(2), D. Haber(3), I. González Hernández(1), F. Hill(1), R. Howe(1), K. Jain(1), S. Tripathy(1)
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Monday May 2, 2011 10:18-10:36am

We will present maps of fluid parameters, such as divergence and vorticity, derived from subsurface flow measurements obtained from HMI Doppler data processed with the HMI ring-diagram pipeline. These quantities are useful, for example, for studying active regions and their evolution. More than six full Carrington rotations have now been analyzed through the HMI ring-diagram pipeline. For comparison, we will include recent results from GONG observations.

The Many Spectra of Sunquakes

Author(s): Alexander Kosovichev
Affiliation(s): Stanford University

Wednesday May 4, 2011 Poster #88

The X2.2-class solar flare of February 15, 2011, produced a powerful `sunquake' event, representing a helioseismic response to the flare impact in the solar photosphere, observed with the HMI instrument on SDO. The flare was also observed with the AIA and EVE instruments, and with the Hinode, RHESSI and FERMI space missions. These data provide a unique opportunity for first high-resolution spatial and spectral analyses of the helioseismic response and its relation to the flare energy release. This event reveals very interesting properties different from the previous sunquakes. In particular, the analysis of the SDO/HMI and X-ray data from RHESSI shows that the helioseismic waves were initiated by the photospheric impact in the early impulsive phase, observed prior to the hard X-ray (50-100 keV) impulse, and were probably associated with atmospheric heating by relatively low-energy electrons (6-50 keV) and heat flux transport. The impact caused a short wave-like motion in the sunspot penumbra prior to the appearance of the helioseismic wave. It is found that the helioseismic wave front traveling through a sunspot had a lower amplitude and was significantly delayed relative to the front traveling outside the spot. The multi-instrument observations of sunquakes open new perspectives for studying the energy release and transport in solar flares and for using the flare-excited waves for sunspot seismology.

Solar and Solar Wind Features that Influence Geoeffectiveness at Earth

Author(s): Janet U. Kozyra
Affiliation(s): University of Michigan

Tuesday May 3, 2011 9:00-9:30am

This presentation summarizes the features of CMEs and CIR/high speed streams that influence their geoeffectiveness at Earth. These features derive from both solar sources and processes that occur during propagation. New evidence suggests that intervals of dominant IMF-By and northward-IMF in the solar wind disturbances have important influences on geoeffectiveness. Recent observations indicate that non-compressive density enhancements (likely pieces of the solar filament itself) intensify the ring current even during northward IMF and are responsible for the creation of new radiation belts. New TWINS and THEMIS observations under obliquely southward IMF conditions indicate that solar wind capture within the dayside magnetopause may provide a previously unidentified source of plasma for the ring current. Inter-hemispheric asymmetries in field-aligned currents during large IMF-By intervals may alter the electrodynamics along closed subauroral field lines possibly influencing mass and momentum coupling between the ionosphere and magnetosphere. These conditions may also be triggering unusual features in observed and modeled auroral activity.

Making Sense of the Soup: SWAMIS Magnetic Feature Tracking for SDO

Author(s): Derek A. Lamb(1), Craig E. DeForest(1), Alisdair R. Davey(2)

Affiliation(s): (1) Southwest Research Institute, Boulder, CO; (2) Harvard Smithsonian Center for Astrophysics

Thursday May 5, 2011 10:36-10:54am

The SWAMIS algorithm is being implemented in two flavors for SDO/HMI line of sight magnetograms. The first flavor (SWAMIS-EF) detects and reports regions of emerging flux to the Heliophysics Event Knowledgebase. We present the performance of SWAMIS-EF during some well-known events, such as the Valentine's Day 2011 flares. The second flavor (Scientific SWAMIS) performs magnetic feature tracking that will be of general use to the community, and is planned for development this summer. It will run at the Harvard Smithsonian Center for Astrophysics. We seek input from the community on the quantities and methods of information dissemination for Scientific SWAMIS.

Extending the Medium-l Program to HMI

Author(s): T. Larson and J. Schou

Affiliation(s): Stanford University

Monday May 2, 2011 Poster #10

As we approach a full year of regular observations from HMI, the MDI project draws to a close. In this poster we discuss a continuation of the MDI Medium-l Program using data from HMI. While agreement between the two instruments is generally quite good, HMI provides an opportunity to finally unravel some of the systematic errors we found in the analysis of MDI data. To that end, we recompute the leakage matrices with different resolutions, apodizations, and point spread functions and compare the resulting mode parameters obtained during the last MDI Dynamics run with contemporaneous results from HMI.

A Comparison of SDO/HMI and Hinode/SP SpectroPolarimetry and Vector Magnetic Field Data (or) It is what it is, isn't it?

Author(s): K. D. Leka

Affiliation(s): NWRA, CoRA Division

Monday May 2, 2011 Poster #13

A comparison is presented between the vector magnetic field data products of SDO/HMI and solar regions co-observed with the Solar Optical Telescope/Spectropolarimeter aboard Hinode. The differences in spatial and spectral resolution between these two instruments are accounted for, and the comparisons are based on both the calibrated Stokes spectra, the polarization sensitivity, and the vector field products retrieved from the two inversions generally associated with these data. This detailed treatment allows for quantitative characterization of the extent to which HMI recovers various solar magnetic field structures as observed by Hinode/SP. This research is funded by the NWRA subcontract from Stanford University NASA Grant NAS5-02139 for SDO/HMI commissioning and pipeline code implementation, NASA contracts NNH09CF22C and NNH09CE60C and the NWRA subcontract from the Smithsonian Astrophysical Observatory under NASA NNM07AB07C.

Coronal Waves in AIA and SXI

Author(s): J. R. Lemen, N. Nitta

Affiliation(s): Lockheed Martin Solar and Astrophysics Lab

Tuesday May 3, 2011 Poster #61

Coronal waves are frequently observed in the low corona with SOHO/EIT during flare and CME initiation. More recently coronal waves have been observed with several of the AIA channels. Coronal waves were observed in connection with three flares observed on 13 February 2011 (M6.6), 14 February 2011 (M2.2), and 15 February (X2.2). GOES 15 SXI also observed these three events with its tin+mesh filter with a ~4 min cadence. The SXI grazing incidence telescope has approximately 10 arcsec resolution (5 arcsec pixels) and the broadband response peaks at 8 MK for the tin+mesh filter. A faint wave signature is detected for each of these flares with velocities >200 km/s, consistent with AIA observations. We compare the SXI wave observations with AIA observations in order to constrain the amount of high temperature plasma that is accelerated in these events.

How Does The Corona Turn into the Heliosphere?

Author(s): Jon A. Linker
Affiliation(s): Predictive Science, Inc.

Tuesday May 3, 2011 5:30-6:00pm

The solar corona expands outward and fills the heliosphere as the supersonic solar wind. That this is a natural consequence of a hot corona was first deduced by Parker over 40 years ago. Since that time there have been numerous observations of the corona and solar wind with increasing resolution and cadence. While coronal/solar wind models have also dramatically increased in sophistication, key questions regarding the origin of the solar wind and its connection to the lower solar atmosphere remain. SDO's global view of the Sun, unprecedented in temporal and spatial resolution, shows dynamic phenomena at all scales and challenges us to understand the multi-scale impact of the corona on the solar wind. In this talk, we discuss the success and limitations of present global models for describing the solar wind. We focus on different ideas for the origin of the slow wind, and we discuss the likely directions for future work. This work is supported by NASA and NSF.

AZAM Disambiguity Utility for SDO/HMI

Author(s): Bruce W. Lites, Rebecca Centeno Elliott
Affiliation(s): HAO/NCAR

Wednesday May 4, 2011 Poster #136

The AZAM utility is a software package for interactive "resolution" of the 180° ambiguity of the transverse component of the magnetic field vector. In addition to this capability, AZAM also provides the user with a platform that performs many other useful tasks involving examination and display of the results of "inversion" of solar Stokes profile measurements. Developed initially during the mid-1990s for use on data from the HAO/NSO Advanced Stokes Polarimeter and written entirely in IDL, AZAM has been extensively modified to work with data from the SDO/HMI instrument. It is implemented in SolarSoft, and will soon be available for use by the community. The interactive ambiguity resolution procedure of AZAM is based on attaining continuity of the field vector over the observed field of view.

Coronal HXR Sigmoid in the Eruption of a Double-Decker Filament

Author(s): Rui Liu, Chang Liu, Haimin Wang
Affiliation(s): NJIT

Wednesday May 4, 2011 5:10-5:28pm

We present the study an active-region filament with a "double decker" configuration, i.e., the filament was composed of two bifurcated branches sharing the same ends. One branch was located above the other, separated by about 13 Mm. This double-decker configuration sustained for days before the upper branch erupted with a GOES-class M1.0 flare on 2010 August 7. We conclude that both branches were embedded in flux ropes with opposite sign of helicity, i.e., the lower branch was associated with a right-handed flux rope in the normal configuration, while the upper branch with a left-handed flux rope in the inverse configuration. The eruption was triggered by flare heating near one end of the filament and driven by the kink instability, as the upper branch writhed into a left-handed kink whose handedness is determined by combining SDO and STEREO observations. Underneath a coronal HXR sigmoid formed rapidly in the gap between the two original branches from about 12 Mm to 25 Mm above the surface as inferred from three-dimensional reconstruction. We suggest that accelerated electrons trapped in a vertical current sheet underlying the writhing filament branch produced the coronal HXR sigmoid.

A Standard-to-Blowout Jet Observed by SDO

Author(s): Chang Liu (1), Na Deng (1,2), Rui Liu (1), Ignacio Ugarte-Urra (3), Shuo Wang (1), Haimin Wang (1)
Affiliation(s): (1) NJIT; (2) CSUN; (3) GMU

Wednesday May 4, 2011 Poster #78

The commonly observed solar jets provide critical information on the small-scale energy release. We report a near disk-center jet on 2010 July 20 observed by SDO, in which the standard interchange magnetic reconnection between a small emerging flux and the ambient open fields is followed by a blowout-like eruption. In our observation, first, as the flux spanning 9 x 10^3 km emerged within a unipolar region at a supergranular boundary, a jet with a dome-like base in EUV grew for 30 minutes before the jet spire began to migrate laterally with enhanced flux emergence. Second, the negative emerging element subsequently collided and canceled with the preexisting positive flux producing a seven-minute A6 microflare. In this stage, the dome of the jet seemed to be blown out as evidenced by several aspects of observations, including that (1) the spire swung faster and exhibited an unwinding motion before vanishing, (2) a rising loop and a blob erupted to stretch open the nearby fields, with the blob spiraling outward in acceleration after the flare maximum, and (3) ejecting material that formed a curtain-like structure at chromospheric to transition-region temperatures also underwent a transverse motion. It is thus suggested that the flare reconnection rapidly removes the outer fields of the emerging flux rope to allow its twisted core field to erupt, which supports the jet-scale magnetic breakout scenario as recently advocated by Moore *et al*. in 2010.

Studying Solar Active Regions with HMI Data

Author(s): Y. Liu(1), J.T. Hoeksema(1), K. Hayashi(1), X. Sun(1), P. Schuck(2), K. Muglach(3)

Affiliation(s): (1) Stanford University; (2) NASA; (3) NASA/Artep, Inc.

Wednesday May 4, 2011 Poster #95

Full disk field of view, continuous time coverage, high temporal and spatial resolutions, and consistent data quality, these specifications of the HMI observational data allows us to study in detail the evolution of solar active regions during the course from emerging to decaying. Using the HMI vector magnetic field data (test version), we study the magnetic energy and helicity in emerging active regions. First, we apply the code DAVE4VM (Schuck 2008) to the time-series vector magnetic field data to derive the plasma velocity; then we break down the energy and helicity fluxes into two parts, one from the "emerging process" and the other from the "shear motion". We analyze the roles these two processes play in accumulating the energy and helicity in the corona, and explore their correlations with the evolution of active regions. Finally we discuss potential impact on the results due to imperfectness of the vector field data.

Direct Imaging by SDO/AIA of Quasi-periodic Fast Mode Magnetosonic Waves Propagating at ~2000 km/s in the Solar Corona

Author(s): Wei Liu, Alan M. Title, Junwei Zhao, Leon Ofman, Carolus J. Schrijver, Markus J. Aschwanden, Bart De Pontieu, and Theodore D. Tarbell

Affiliation(s): Lockheed Martin Solar and Astrophysics Laboratory, Department ADBS; W. W. Hansen Experimental Physics Laboratory, Stanford University, Stanford, CA 94305; Catholic University of America and NASA Goddard Space Flight Center, Code 671, 8800 Greenbelt Road, Greenbelt, MD 20771

Wednesday May 4, 2011 12:50-1:08pm

Quasi-periodic, propagating fast mode magnetosonic waves in the corona were difficult to observe in the past due to relatively low instrument cadences. We report here unprecedented, unequivocal evidence of such waves directly imaged in EUV by the new SDO/AIA instrument. In the 2010 August 1 C3.2 flare/CME event, we find arc-shaped wave trains of 1-5% intensity variation emanating from the flare kernel and propagating outward along a funnel of coronal loops at ~2000 km/s. Similar wave trains propagating in opposite directions are observed in closed loops connecting two flare ribbons. In the k-omega diagram of the Fourier wave power, we find a bright ridge that represents the wave dispersion relation and can be well fitted with a straight line passing through the origin, giving equal phase and group velocities of 1630 +/- 760 km/s. This k-omega ridge shows a continuum frequency distribution with the strongest frequency at 14.5 mHz (period P=69.0 s). The observed EUV intensity fluctuations are most likely a result of plasma density modulation produced by fast magnetosonic waves.

SDO/AIA Observations of Coronal Condensation Leading to Prominence Formation

Author(s): Wei Liu, Thomas Berger, B. C. Low, Roberto Casini

Affiliation(s): Lockheed Martin Solar and Astrophysics Laboratory, Department ADBS; W. W. Hansen Experimental Physics Laboratory, Stanford University; High Altitude Observatory

Wednesday May 4, 2011 4:52-5:10pm

Coronal condensation, as a likely source of prominence mass, takes place when million degree coronal plasma undergoes catastrophic cooling due to radiative instability. Direct observation of coronal condensation in prominences has been difficult in the past because of the relatively low spatial resolution and high scattered light characteristics of ground-based instruments. However, with the launch of the Hinode/SOT and SDO/AIA instruments, numerous H-alpha, Ca II H-line, and He II 304 Å observations of plasma condensing "out of nowhere" high up in quiescent prominences have been captured. We present here one such event seen with SDO/AIA. On 25-Nov-2010, a prominence above the southwest limb is swept away by a nearby eruption, and for next a few hours there is no visible 304 Å material in the local corona. Then, a portion of the coronal loops at the same location progressively sags and forms a local dip, where the first sign of new, cool material appears, 7.5 hours after the eruption. This is a clear indication of coronal condensation, and the gradual sag of the loops is likely a result of increasing weight of the condensed material that has been accumulated at the dip. Similar condensation occurs nearby at a larger rate and leads to the formation of a moderate-size prominence. The estimated prominence mass increases linearly for about 7 hours at a rate of 2.6e10 grams/sec and reaches approximately 6x10^14 grams. Simultaneously, the prominence drains through vertical flows of approximately 32 km/s, bringing the mass back to the chromosphere. We estimate the mass drain rate to be 2.7e10 grams/sec, which, together with the estimated mass accumulation rate, implies a coronal condensation rate of approximately 5.3e10 grams/sec. These are preliminary results enabled by the extremely low scattered light and high spatio-temporal resolution characteristics of AIA. Refinements of this study can provide critical information about the coupling between condensation energetics and MHD, prominence mass cycles, and coronal mass ejections initiated by loss of anchoring prominence mass (e.g., Low 2001).

Heating of Flare Loops During a Two-ribbon Flare on 2005 May 13

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Affiliation(s): Department of Physics, Montana State University, Bozeman MT 59717

Tuesday May 3, 2011 Poster #69

Many eruptive flares exhibit two extended ribbons in the lower-atmosphere outlining the feet of the post-flare coronal arcade. High-cadence and high-resolution UV observations by TRACE reveal that the flare ribbon consists of small patches sequentially brightened along the ribbon, suggesting that reconnection takes place sequentially forming individual post-flare loops along the arcade, as often seen in coronal observations in the EUV wavelengths. These reconnection events and formation of new loops continue well into the decay phase. Our recent study (Qiu *et al*. 2010) further shows that the spatially resolved UV brightness at the foot-points of individual loops grows rapidly on timescales of ~1 minutes, followed by a long decay on timescales of more than 10 minutes. The rapid rise of UV radiation is correlated with the hard X-ray light curve during the impulsive phase, hence is most likely a direct response of instantaneous heating in the reconnection formed flux tubes. In this study, we utilize the spatially resolved UV brightness time profiles to reconstruct instantaneous heating functions of individual flux tubes, and compute evolution of each flux tube using the EBTEL model (Klimchuk *et al*. 2008). To build the heating function, we take into account the scaling between the total UV peak count rate, the hard X-ray energy flux derived from RHESSI spectral analysis during the impulsive phase, and as well the reconnection rate that persists from the pre- impulsive phase to the decay phase. The sum of the computed coronal radiation in all the flux tubes compares favorably with the gross coronal radiation observed by GOES. This study presents the first effort to constrain heating functions of flare loops directly using all available observables, and provides a powerful way to examine physics of heating discrete flux tubes formed by reconnection events throughout the flare.

Wavefront Expansion and Dispersion of Coronal Bright Fronts

Author(s): David M. Long, Edward E. Deluca & Peter T. Gallagher

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Wednesday May 4 2011 2:20-2:38pm

The true nature of Coronal Bright Fronts (CBFs; commonly called "EIT Waves") remains enigmatic despite more than ten years of research. High cadence contemporaneous observations from the Solar Dynamic Observatory (SDO) and Solar TErrestrial RElations Observatory (STEREO) spacecraft are used here to determine the kinematics and dispersion of a CBF pulse observed on 2010 August 14. The CBF exhibited clear deceleration with propagation, with lower initial velocity and weaker deceleration in STEREO observations compared to SDO. The kinematics of the CBF were found to be highly passband dependent, with the pulse exhibiting higher initial velocity and stronger deceleration in cooler passbands. Significant pulse broadening was also measured using both STEREO (~55 km/s) and SDO (~65 km/s) observations. The dispersion rate of the pulse was derived by modeling the CBF as a linear superposition of sinusoidal waves within a Gaussian envelope. These results imply that the observed CBF is a fast-mode magnetoacoustic wave, and allowed the quiet coronal magnetic field strength to be estimated at ~1-2 G.

Computing Magnetic Energy from AIA Images and HMI Line-of-sight Magnetograms

Author(s): Dana Longcope(1), Anna Malanushenko (1,2), Lucas Tarr (1)

Affiliation(s): (1) Montana State University; (2) Lockheed Martin Space and Astrophysics Laboratory

Wednesday May 4, 2011 Poster #106

The state of the art for computing the magnetic energy in an active region's corona is to extrapolate a non-linear force-free field from vector magnetic field data. This method infers coronal properties from photospheric data without direct use of any coronal information. We present here an alternative which uses the shapes of loops visible in EUV or soft X-ray images to infer coronal currents. The method of Malanushenko *et al*. (2009) is used to infer magnetic field strength along each coronal loop. This sparse sampling of magnetic information is used in a Monte Carlo integral to compute the total magnetic energy. We also present a method for computing the free energy (the difference between the energy of the actual field and the corresponding potential field) directly as a single Monte Carlo integral. Both integrals are estimates with known statistical uncertainties which are reasonably small for samples as small as 25 loops. We demonstrate the method using a test field and then apply it to AIA observations of an active region in several wavelengths. We use the line-of-sight measurements from HMI to perform the extrapolations.

Solar Magnetic Field Structures

Author(s): Henrik Lundstedt(1) and Tomas Persson(2)

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Tuesday May 3, 2011 Poster #51

The topology of a magnetic field is, generally speaking, determined by the mutual position of the magnetic field lines, their links and their orientation in space. In previous work we have explored Lorenz-type differential equations, as models of a solar dynamo, the action of the sustaining and exciting of a magnetic field. In the study Poincaré maps gave numerical evidence that the flow has an attractor with fractal structure. In this work, by using photospheric magnetic field observed with HMI onboard SDO, we try to estimate the fractal dimension and herewith the complexity of the field. This is done by analyzing energy integrals with respect to measures associated to the images. Finally, AIA SDO observations of two eruptive prominences/filaments will be described as examples of braided magnetic flux tubes. The complexity and the location of the eruptions are discussed.

Observations and Interpretation of a Low Coronal Shock Wave Observed in the EUV by the SDO/AIA

Author(s): S. Ma (1), L. Golub (1), J. Lin (2), J. Raymond (1), H. Chen (3), P. Grigis (1), P. Testa (1), D. Long (1,4)

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Wednesday May 4, 2011 1:44-2:02pm

Taking advantage of both the high temporal and spatial resolution of the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO), we studied a limb coronal shock wave and its associated extreme ultraviolet (EUV) wave that occurred on 2010 June 13. Our main findings are (1) the shock wave appeared clearly only in the channels centered at 193 Å and 211 Å as a dome-like enhancement propagating ahead of its associated semi-spherical CME bubble; (2) the density compression of the shock is 1.56 according to radio data and the temperature of the shock is around 3 MK; (3) the shock wave first appeared at 05:38 UT, 2 minutes after the associated flare has started and 1 minute after its associated CME bubble appeared; (4) the top of the dome-like shock wave set out from about 1.23 R_sun and the thickness of the shocked layer is 2x10^4 km; (5) the speed of the shock wave is consistent with a slight decrease from about 600 km/s to 550 km/s; (6) the lateral expansion of the shock wave suggests a constant speed around 400 km/s, which varies at different heights and direction. Our findings support the view that the coronal shock wave is driven by the CME bubble, and the on-disk EUV wave includes both a fast mode wave component and a non-wave component the interaction between the wave and surrounding magnetic structures.

Models of the Coronal Magnetic Field Using Input From EUV Images

Author(s): Anna Malanushenko(1, 2), Marc DeRosa(2), M. S. Wheatland(3), Stuart Gilchrist(3), Carolus Schrijver(2)

Affiliation(s): (1) Montana State University; (2) Lockheed Martin Solar and Astrophysics Laboratory; (3) The University of Sydney

Tuesday May 3, 2011 10:54-11:12am

EUV images of the solar corona feature coronal loops which are believed to follow lines of the coronal magnetic field. These loops could in principle be used as an additional input for extrapolating the coronal magnetic field. Recently a lot of progress has been made in recovering the individual field lines best-matching the individual loops. The next step would be to use these individual field lines to construct self-consistent volume-filling models of force-free magnetic fields using this additional input as well as line of sight magnetograms. Given the difficulties associated with using vector magnetograms for non-linear force-free extrapolations, using coronal loops appears to be a promising approach to this problem. AIA full-disk images in many wavelengths in unprecedented temporal and spacial resolution provide valuable data for such modeling. We show the first results of reconstructing individual magnetic field lines based on loop tracing in AIA images guided by linear force-free fields using HMI magnetograms. We also present preliminary results from a newly developed nonlinear force-free field algorithm that uses these loop traces as an additional constraint.

Simulations of the Interior and Atmosphere of the Sun

Author(s): N. N. Mansour, A.A. Wray, A.G. Kosovichev, I.N. Kitiashvili, T. Hartlep, J. Zhao

Affiliation(s): NASA/Ames & Stanford University

Tuesday May 3, 2011 Poster #36

The objective of the research is to improve our understanding of the turbulent dynamics of the Sun through advanced 3D numerical simulations and subgrid-scale turbulence modeling of the complex multi-physics phenomena that drives the solar variability. Turbulence models developed originally for engineering applications and validated using canonical turbulent flows and flow field measurements are used to simulate the near-surface solar convection and lower atmosphere. Results from radiative MHD simulations reproduce many observed features of the Evershed effect, including the high-speed "Evershed clouds," the filamentary structure of the flow, and its nonstationary quasiperiodic behavior. These results are used to argue that the key mechanism of the Evershed effect is in nonlinear magneto-convection that has properties of traveling waves in the presence of a strong, highly inclined magnetic field. Other MHD simulation results reveal a process of spontaneous formation of stable magnetic structures, which may be a key to understanding of the magnetic self-organization on the Sun and formation of pores and sunspots. Future plans include continued leveraging of numerical technologies and turbulence models developed at the Center for Turbulence Research by either including the new models into our solar codes, or in some cases adapting the engineering codes to study the multi-physics phenomena that are dominant in the Sun.

Stages in the Long-term Buildup to Eruptive Events

Author(s): S.F. Martin and O. Panasenco (1); Y. Lin and O. Engvold (2); A. Pevtsov, (3) NSO/Sacramento Peak, NM, USA (3); N. Srivastava (4)

Affiliation(s): (1) Helio Research, La Crescenta, CA, USA; (2) Institute for Theoretical Astrophysics, University of Oslo, Norway; (3) NSO/Sacramento Peak, NM, USA; (4) Udaipur Solar Observatory, India

Wednesday May 4, 2011 Poster #103

Because erupting filaments and CMEs universally occur over filament channels, we deduce that filament channels are the common denominator among all eruptive events

with CMEs. Filament channels serve as a bridge that links photospheric magnetic field processes below them to overlying filaments, occasional sigmoids, and to encompassing systems of coronal loops. The stages that we hypothesize to be essential to eruptive events begin at the photosphere and fall into categories and long-term processes as follows:

A. Source Dynamics

1. constant convection on the scale of supergranules together with ...
2. growth and expansion of active region magnetic fields, at all phases of their lifetimes, among supergranules that stochastically results in ...
3. convergence of opposite polarity magnetic fields beneath skewed coronal loop systems which leads to...

B. Key Processes

4. long-enduring series of fine-scale magnetic reconnections near the photosphere accounting for the observed cancelling of abutted opposite polarity network (or active region) fields that halt intermixing of opposite polarity magnetic fields and lead to ...
5. the creation and maintenance of filament channels which are usually followed by ...
6. the formation and maintenance of a filament spine by the rising of thin threads carrying mass into the low corona followed by ...
7. filament mass draining out of each thread and leaving behind invisible magnetic flux which adds to the magnetic field of the filament cavity; many such additions of magnetic threads to the cavity eventually puts more flux in the cavity than exists in the overlying coronal loop system; hence the magnetic pressure of the cavity eventually exceeds that of the containment field which initiates a rising of the whole system followed by its eruption.

We suggest that these stages apply to all eruptive events from those in active regions to those on the quiet Sun. However, sometimes filament channels lose most or all evidence of a filament but still a CME occurs above the apparently empty filament channel. In at least some of these cases, we suggest that the buildup might be interrupted prematurely or that an eruptive event might be catalyzed by magnetic field interactions of a new active region with the magnetic loops overlying a filament channel. In these cases, the buildup continues but under new or different sets of coronal loops. Our work on the long-term buildup is supported by NSF grant ATM0837915 and work by SFM and OP on the catalyzing of eruptions by NSF SHINE grant ATM-0852249.

Forward Modeling in SDO/AIA Passbands: 3D Dynamic Realistic Models

Author(s): Juan Martínez-Sykora(1,2), Bart De Pontieu(1), Viggo H. Hansteen(2) Paola Testa(3)

Affiliation(s): (1) Lockheed Martin Solar & Astrophysics Lab; (2) Institute of Theoretical Astrophysics, University of Oslo; (3) Smithsonian Astrophysical Observatory

Monday May 2, 2011 12:50-1:08pm

The emission from many of the passbands observed with the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) is dominated by single or several lines from ions that are formed in a narrow range of temperatures (under equilibrium conditions). However, most AIA passbands contain contributions from lines of ions that have formation temperatures that are significantly different from the dominant ion. We investigate the importance of these lines by forward modeling of the AIA passband emission from advanced radiative 3D MHD simulations calculated with the state of the art Bifrost code. We use simulations that span the upper layer of the convection zone to the low corona and solve the full magnetohydrodynamic equations with non-grey and non-LTE radiative transfer and thermal conduction along the magnetic field lines. We find that several of the AIA passbands often include significant contributions from plasma at different temperatures than the canonical temperature values. We describe under which solar conditions in the simulations these discrepancies can typically be expected to occur.

Using AIA to Continue Solar Irradiance Forecasting

Author(s): James P. Mason, Juan Fontenla

Affiliation(s): Laboratory for Atmospheric and Space Physics

Wednesday May 4, 2011 Poster #122

AIA will be critical in the continuation of the EUV forecasting method developed in Fontenla *et al*.(2009) and references therein. In order to use this new dataset, it must first be characterized and understood. This involves comparing the center to limb variation with existent feature models, generating histograms to scale the intensity threshold levels used for generating feature masks, and finally choosing that wavelengths that compare best with previously used observations.

Egression Analysis of the February 15 SDO Sun-quake

Author(s): S.A. Matthews, L. Green, E. Pedram, V.V. Zharkova

Affiliation(s): MSSL, UCL; University of Bradford

Wednesday May 4, 2011 Poster #89

Following A. Kosovichev's RHESSI nugget, we present the results of our investigation of the acoustically active X-class flare of February 15, 2011, observed by Solar Dynamics Observatory. We use HMI data to measure acoustic emissions and locate corresponding photospheric seismic sources associated with this flare. We carry out frequency and time-distance analysis to determine properties of such sources. The locations and strengths of seismic signatures are compared with other AIA and RHESSI measurements. Possible implications of these findings for physical processes in this flare are discussed.

Properties of Geo-effective Stream Interactions and CMEs During the Recent Solar Minimum

Author(s): M. Leila Mays, O. C. St. Cyr, David G. Sibeck, and Barbara J. Thompson

Affiliation(s): NASA Goddard Space Flight Center

Monday May 2, 2011 Poster #3

A statistical study of stream interactions and CME events from 2007 to 2010 which result in storm and substorm activity is presented. During this solar minimum the decrease in solar activity has resulted in less geomagnetic activity. The observed activity, which ultimately arises from changes in the solar wind, has been from stream interactions regions (SIRs), shocks, and some interplanetary coronal mass ejections (ICMEs). Geomagnetic activity is characterized by indices derived from ground based magnetometers. For each geomagnetic event, we identified CMEs in the STEREO/SECCHI coronagraphs, and SIRs in the STEREO/SECCHI Heliospheric Imagers and associated lower coronal signatures in STEREO/EUVI and SDO/AIA. Subsequent CME and/or SIR signatures were indentified in ACE, WIND, THEMIS, and other in-situ data when available. CME evolution in the lower corona and properties such as acceleration, speed and width were determined along with the in-situ plasma data for ICMEs. The propagation of these structures were tracked in the STEREO Heliospheric Imagers and subsequently in-situ. Geoeffectiveness, the strength and duration of geomagnetic activity, is compared with upstream solar wind conditions. In 2007 and 2008, SIRs produce most of the storms (~75% and ~78% respectively), however the strongest storms are produced by ICME and SIR interactions in 2007 and SIRs in 2008. The number of SIR driven storms drops to just below half (~46%) in 2009, and the remaining storms mostly result from ICME and SIR combinations which produce one strong storm. In 2010 the number ICME driven storms markedly increase (~43%) and produce ~57% of the strongest storms while SIR driven storms continue to decrease (~31%).

Exploring Dominant Patterns of Curvature of Super Penumbral Fibrils

Author(s): Brittany McCrigler, Seth Lacy, and Sara Martin

Affiliation(s): Helio Research

Tuesday May 3, 2011 Poster #45

The threads extending from the penumbra of sunspots to the surrounding solar surface, called super penumbral fibrils, have been observed to often have dominant systematic curvatures in clockwise or counterclockwise senses. Previous research has not yet yielded a complete understanding of this curvature. The objective of this study is to determine whether the curvature of super penumbral fibrils is a fundamental characteristic of the sunspot and its magnetic field, a secondary effect of surface and atmospheric motions, or whether there is evidence for some other cause. This study is conducted in two parts, Part I, the foundational work, conducted in 1994 and Part II, a further study conducted in 2010. Part I examines two proposed hypotheses for super penumbral fibril handedness previously suggested by Hale (1925), Richardson (1941) and Peter (1995) (i.e. charged particle and flux rope models) and develops a method for quantifying the magnitude of curvature of super penumbral fibrils. Part II builds from the results from Part I and reevaluates them with consideration to subsequent research in chirality (or handedness) of solar features. It has been shown that nearly all forms of chirality fit within one of two equal and opposite chiral systems. From this perspective a new hypothesis is suggested: the handedness of super penumbral fibrils is a consequence of their belonging to or being influenced by a chiral system. The nature of these chiral systems is discussed. This study finds no evidence in support of the flux rope model and remains neutral on attributing the previously found hemispheric patterns of chirality to either a twisted flux rope or surface motions. A one-to-one correlation is verified between the respective chiralities of super penumbral fibrils and the chiralities of nearby filaments. A corresponding relationship is shown between the magnitude of curvature of super penumbral fibrils and the distance between the sunspot and related filament. Other factors statistically shown to have no relationship to the handedness or curvature of super penumbral fibrils are: sunspot diameter, latitude, and surrounding magnetic field complexity. While chiral systems cannot be proven to account of all of the curvature of super penumbral fibrils the results of this study favor the presented hypothesis over previous theories.

Direct Measurement of Strong Alfvénic Motions Throughout the Hot Outer Solar Atmosphere

Author(s): Scott W. McIntosh, Bart De Pontieu, Mats Carlsson, Viggo Hansteen, Paul Boerner

Affiliation(s): NCAR/HAO, LMSAL, UiO

Tuesday May 3, 2011 5:12-5:30pm

Alfvén waves have been invoked as a possible mechanism for the heating of the Sun's outer atmosphere or corona to millions of degrees and for the acceleration of the solar wind to hundreds of km/s. The generation and propagation of these incompressible and transverse oscillations of the magnetic field allows magneto-convective energy to be transported upward along the Sun's magnetic field and deposited in the Sun's outer atmosphere and heliosphere. However, Alfvén waves of sufficient strength have never been directly observed in transition region and coronal emission. Here we show that the entire outer solar atmosphere is permeated by Alfvén waves that are energetic enough to accelerate the solar wind and heat the quiet corona. The unprecedented spatial and temporal resolution of our observations with the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) satellite reveals for the first time that the extremely dynamic and finely structured outer solar atmosphere undergoes vigorous Alfvénic motions with amplitudes of order 20 km/s. The outwardly-propagating Alfvénic motions

observed have periods of order 100-500s throughout the atmosphere, consistent with recent investigations. Our observations establish that the energetics of the outer solar atmosphere are significantly affected by Alfvén waves. Our results provide constraints for recent self-consistent models of atmospheric heating and wind acceleration by low-frequency Alfvén waves.

Preliminary Exploration of the Magnetic Field Between Two Opposite-Hemisphere Active Regions

Author(s): David E. McKenzie, Dana W. Longcope
Affiliation(s): Montana State University

Tuesday May 3, 2011 Poster #52

In March 2011, AIA images showed coronal loops associated with active regions in both north and south hemispheres. The observed loops suggest interaction between the two active regions (ARs), although trans-equatorial loops were not initially observed to connect the ARs. We employ photospheric magnetograms to construct a preliminary magnetic model--including the inter-AR region--in order to investigate the topology of their interaction: null point, current sheet, or both.

MHD Modeling of the Sympathetic Eruptions Observed on August 1, 2010

Author(s): Z. Mikic, T. Torok, V. Titov, J. A. Linker, R. Lionello, and P. Riley
Affiliation(s): Predictive Science, Inc.

Wednesday May 4, 2011 10:18-10:36am

The multiple solar eruptions observed by SDO on August 1, 2010 present a special challenge to theoretical models of CME initiation. SDO captured in detail a remarkable chain of sympathetic eruptions that involved the entire visible hemisphere of the Sun (Schrijver *et al*. 2010). It consisted of several flares and six filament eruptions/CMEs, and triggered a geomagnetic storm on August 3 (de Toma *et al*. 2010). This series of eruptions was also observed by the two STEREO spacecraft. This collection of observations presents a unique opportunity to understand sympathetic eruptions theoretically. We will present 3D MHD simulations of these events that have helped us to understand the possible mechanisms by which the various filament eruptions/CMEs may be linked, with particular emphasis on the global topology of the coronal magnetic field in which these structures are embedded.

SDO/EVE Learning Suite for Educators

Author(s): Emily Morton and Mark McCaffrey
Affiliation(s): CIRES at University of Colorado Boulder

Tuesday May 3, 2011 Poster #73

The SDO/EVE Education and Public Outreach (EPO) program, led by the Cooperative Institute for Research in Environmental Sciences' Education and Outreach group (CIRES EO) at the University of Colorado has developed and deployed education materials that build on one another and create a comprehensive learning suite for educators. The mutual goals of CIRES EO SDO/EVE program are to:

1) Engage students in experiential hands-on science and independent research experiences, and enhance an interest and understanding of solar science and space weather via our Solar Learning Kits.
2) Provide professional development for science teachers to understand solar science and deliver inquiry-based science activities, via online learning modules that highlight quality educational materials.
3) Engage scientists in education outreach to enhance science literacy through educational videos that provide explanation and examples of solar phenomena and data from SDO/ EVE.

CIRES EO will continue this education series by providing virtual learning tools with a multimedia-oriented approach that provide options for both synchronous and asynchronous communication with teachers and students.

JHelioviewer - Open-Source Software for Discovery and Image Access in the Petabyte Age

Author(s): D. Mueller, G. Dimitoglou, M. Langenberg, M. Nuhn, J.P. Garcia Ortiz, A. Dau, S. Pagel, L. Schmidt, V.K. Hughitt, J. Ireland, B. Fleck
Affiliation(s): ESA

Monday May 2, 2011 Poster #6

JHelioviewer: Open-Source Software for Discovery and Image Access in the Petabyte Age The unprecedented torrent of data returned by the Solar Dynamics Observatory is both a blessing and a barrier: a blessing for making available data with significantly higher spatial and temporal resolution, but a barrier for scientists to access, browse and analyze them. With such staggering data volume, the data is bound to be accessible only from a few repositories and users will have to deal with data sets effectively immobile and practically difficult to download. From a scientist's perspective this poses three challenges: accessing, browsing and finding interesting data while avoiding the proverbial search for a needle in a haystack. To address these challenges, we have developed JHelioviewer, an open-source visualization software that lets users browse large data volumes both as still images and movies. We did so by deploying an efficient image encoding, storage, and dissemination solution using the JPEG 2000 standard. This solution enables users to access remote images at different resolution levels as a single data stream. Users can view, manipulate, pan, zoom, and overlay JPEG 2000 compressed data quickly, without severe network bandwidth penalties. Besides viewing data, the browser provides third-party metadata and event catalog integration to quickly locate data of interest, as well as an interface to the Virtual Solar

Observatory to download science-quality data. As part of the Helioviewer Project, JHelioviewer offers intuitive ways to browse large amounts of heterogeneous data remotely and provides an extensible and customizable open-source platform for the scientific community.

Plasma Heating During Coronal Mass Ejections Observed by SOHO and SDO

Author(s): Nicholas A. Murphy, John C. Raymond, and Kelly E. Korreck

Affiliation(s): Harvard-Smithsonian Center for Astrophysics

Wednesday May 4, 2011 Poster #83

Several recent observational results suggest that coronal mass ejection (CME) plasma is heated even after leaving the flare site. The source of the heating is probably the magnetic field, but the mechanisms that convert magnetic to thermal energy during these events are not well understood. In the context of CMEs observed by SOHO/UVCS and SDO/AIA, we use a time-dependent ionization code to constrain plasma heating and determine the efficacy of several different candidate heating mechanisms. In particular, we present further evidence for continued heating.

Comparison of Properties of SDO/HMI and Hinode/SOT Helioseismology Datasets

Author(s): Kaori Nagashima(1), Junwei Zhao(1), Alexander G. Kosovichev(1), Takashi Sekii(2)

Affiliation(s): (1) Stanford University, (2) NAOJ

Monday May 2, 2011 Poster #8

We investigate dynamics of high-latitude regions of the Sun by exploiting high-resolution datasets obtained by the Solar Optical Telescope (SOT) on board the Hinode satellite during the periods of high inclination of the solar axis to the ecliptic. Since the field of view of SOT is limited, combining the SOT high-resolution observations with HMI full-disk observations provides us a good opportunity to investigate the dynamics in more detail. In this presentation, we compare the basic properties of the observations of solar oscillations from the SOT and HMI, as well as the travel-time signals obtained in the high-latitude regions, and discuss implications of these measurements for local helioseismology studies of the solar dynamics.

Chromospheric Evaporation Seen at HXR

Author(s): Ning Zongjun

Affiliation(s): Purple Mountain Observatory, Beijing West Road, No.2 210008, Nanjing, China

Monday May 2, 2011 Poster #22

Chromospheric evaporation is the mass upflow along the loops from the chromosphere layer to corona. Such process indicates the movement of HXR emission targets. From the observations, HXR shows the double footpoint sources rising upward along the flaring loop and finally merging into a single source at the same position as the looptop source. Here we present the observational evidences of chromospheric evaporation from RHESSI observations.

Study of EIT Waves as Observed by SDO AIA and STEREO EUVI

Author(s): N. V. Nitta, C. J. Schrijver, A. M. Title, J. R. Lemen, S. L. Freeland, W. Liu, P. Boerner

Affiliation(s): Lockheed Martin Solar and Astrophysics Laboratory

Wednesday May 4, 2011 2:02-2:20pm

Using SDO AIA data, we have studied several cases of global disturbances that may correspond to the phenomena often generalized as the "EIT wave". One of our primary purposes is to isolate wave signatures from projected CME loops, which can now be much less ambiguously done by combining the AIA with the EUVI and COR1 observations from the two STEREO spacecraft, recently in near quadrature with respect to the Sun-Earth line. We associate the properties of the propagating fronts with those of the associated phenomena including CMEs, flares and radio bursts, and discuss their dependence on the evolution of the source active regions and surrounding areas. In order to better understand the (presumably CME) origin of these disturbances, we discuss the relation between the propagating fronts and dimming, both persistent and transient, in both running and base difference images from AIA and EUVI. We also extract global disturbances in high-temperature channels, by averaging the images temporally, and derive plasma parameters at the fronts, which may help us better characterize the phenomena.

Interplay of Magnetic Field Connection and Large-Scale Coronal Disturbances on the Time Variations of Gradual SEP Events

Author(s): N. V. Nitta

Affiliation(s): Lockheed Martin Solar and Astrophysics Laboratory

Wednesday May 4, 2011 Poster #85

Solar energetic particle (SEP) events with elevated flux in protons are called gradual due partly to their associations with solar flares that last long (long duration events, LDEs). It is widely believed that particles in these events are accelerated at CME-related shocks. Magnetic field connection of the flare region is not as actively discussed for this type of SEP events as for 3He-rich SEP events because the shock is extended and at least some part of it may be magnetically connected to the observer, at least on a cartoon level. The estimated particle release time is often found to be delayed with respect to the flare, leading to the hypothesis that the shock may form only when the CME reaches a

certain height. We may consider a different scenario, in which more particles are accelerated at lower part of the shock and they may not be released until that part of the shock intersects with well-connected field lines. It is possible that some of the large-scale disturbances or coronal waves, as observed in EUV wavelengths, may signify shocks, which may accelerate particles. In a handful of small proton events that occurred in 2010, we track the coronal waves in images from SDO AIA and STEREO EUVI with respect to the well-connected field lines obtained using the potential field source surface (PFSS) model. We discuss this analysis in comparison with the time profiles of electrons at Earth and STEREO A and B early in the events.

Ab Initio Solar Active Region Simulations

Author(s): Åke Nordlund and Anders Lagerfjärd

Affiliation(s): Niels Bohr Institute

Tuesday May 3, 2011 1:08-1:26pm

We report on a variety of ab initio numerical simulations of solar active regions. The simulations cover volumes with horizontal sizes ranging from 12x12 Mm to 48x48 Mm, have vertical extents of 20 Mm, and employ numerical mesh resolutions up to 2016x2016x500. One set of models start from field free convection, with bottom boundary conditions that sample from a uniform horizontal magnetic field in fluid upflows. Such models must be evolved for many solar hours before a quasi-steady state is reached. Horizontal rms fluctuations of the magnetic field scale approximately as the square root of the mean density in the quasi-steady states. This motivates a second set of models, where the initial state has a horizontally uniform magnetic field, which varies in strength in proportion to the square root of the mean density. Even though the initial magnetic field is horizontally uniform such models quickly develop structures similar to the ones in the first set of models, and they thus represent a faster route to achieving realistically structured magnetic fields on active region scales. A third set of models are intended to represent patches of active regions with plages, pores, and small sunspots. Initial conditions with representative average magnetic flux densities are created by first evolving magnetoconvection starting with an initially uniform, weak vertical magnetic field. The hierarchical convection patterns in the volume distorts the magnetic field into a structure that reflects the multi-scale nature of the velocity field. Over a few dynamical times the strength of the magnetic field is then artificially increased, until the desired average flux of the initial state is obtained. We present several examples of synthetic Stokes spectra computed from these sets of models, using 3-D versions of the LILIA and NICOLE codes. For the plage models the synthetic model spectra have subsequently been analyzed with the HELIX inversion code, after passing through a realistic model of a point spread function, consisting of an Airy function core and a Gaussian scattered light component. An important application of these active region models is to function as "drivers" of chromospheric and coronal dynamics. This is achieved by rerunning selected portions of the simulation sequences, with the vertical extent increased to include a model corona. The physics of the corona model is similar to previous models by Gudiksen & Nordlund (2005), Peter *et al* (2006) and Bingert *et al* (2011), except here the driving is selfconsistently supplied by active region size magnetoconvection, and is transmitted to the corona by both via flux emergence and by multi-scale stressing of the coronal magnetic field.

Magnetogram Time Series Observed with HMI

Author(s): A.A. Norton(1), J. Schou(2), Y. Liu(2), J.T. Hoeksema(2)

Affiliation(s): (1) James Cook University, Australia; (2) Stanford University, USA

Thursday May 4, 2011 10:54-11:12

The HMI line-of-sight magnetogram time series are significantly 'cleaner' than the precursor MDI magnetogram data. There is less leakage of p-mode signal into the HMI magnetogram data for several reasons. We show magnetic time series and power spectra observed by HMI for sunspot, plage and quiet-Sun and compare it to MDI. We discuss the implications, especially the possibility of constraining amplitudes of MHD waves present in the photosphere.

SDO/AIA Observations and Models of Kelvin-Helmholtz Instability in the Solar Corona

Author(s): L. Ofman and B.J. Thompson

Affiliation(s): Catholic University of America; NASA Goddard Space Flight Center, Code 671

Wednesday May 4, 2011 Poster #97

Observations of Solar Dynamics Observatory (SDO) of Apr 8, 2010 CME shows evidence of Kelvin-Helmholtz instability at the boundary between the erupting (dimming) region and the 'quiet Sun' corona. The evidence appears in the form of traveling vortices ranged in size from several to ten arcseconds, propagating along the interface at speeds of 6-14 km/s. The features are clearly visible in six out of the seven different EUV wavebands of the Atmospheric Imaging Assembly (AIA) suggesting that these are coronal plasma motions. Using erupting overlaying loop motions we estimate the velocity shear between the two regions at ~20 km/s. Further, we develop a 2.D MHD model of the KH instability guided by the observations and the typical parameters of a coronal plasma. We find that the MHD model reproduces important aspects of the observation in support of our theoretical interpretation. We conclude that the identified small scale traveling features are the first observations of the Kelvin-Helmholtz (KH) instability in the corona in EUV that became possible thanks to the high cadence and resolution of AIA on SDO.

The Hitchhiker's Guide to Filament Chirality

Author(s): Olga Panasenco
Affiliation(s): Helio Research, La Crescenta, CA

Wednesday May 4, 2011 4:00-4:18pm

Filaments and prominences have been observed since Secchi, 1860. Still, many properties remain mysterious and are often misunderstood. There are many models for prominence formation and prominence eruption ranging from theoretical to empirical and even just plain cartoons. The models are of interest in so far as they may be used to ascertain the physical properties of filaments. Here we show how one such important property, chirality, can be easily and definitely determined based on the wide body of observational evidence first assembled into an empirical model by Martin *et al*. (1985). Chirality is related to a fundamental physical characteristic of the magnetic structure of filaments, namely magnetic helicity. This guide illustrates chirality determination using recent filament eruption examples observed by SDO, including the famed eruption of August 1, 2010.

Magnetic Structure of Twin Filaments Inside Pseudostreamers

Author(s): Olga Panasenco(1) and Marco Velli(2)
Affiliation(s): (1) Helio Research; (2) JPL CalTech

Wednesday May 4, 2011 Poster #108

Pseudostreamers appear in globally unipolar regions above multiple polarity reversal boundaries. Some of these polarity reversal boundaries can be filament channels, and when this is the case they always occur as twin filament channels often containing twin filaments. The magnetic structure of pseudostreamers, as reconstructed with the PFSS model, for cases with and without twin filaments lying at their base, is significantly different. Branches of pseudostreamers on opposite sides of the separatrix surface diverge when filaments are present. Here we analyze possible current and magnetic field configurations of the complete pseudostreamer system and study the links between its separate parts, which include open field lines of pseudostreamers, filament channels, filaments, cavities, overlying filament arcades. The presence of well developed filaments of the same chirality at the base of pseudostreamers is consistent with the presence of a vertical pseudostreamer field-aligned current sheet, which divides and repels branches of the pseudostreamer field lines in 3D. We discuss the 3D magnetic topology of the filament, filament cavity and overlying filament arcades for these twin systems and its implications on the theories for filaments and filament eruptions.

Transformation of MHD Waves in Sunspots and Modeling of the HMI Level 1 Data Using Radiation Transfer Simulations

Author(s): K.V. Parchevsky, A.G. Kosovichev
Affiliation(s): Stanford University

Tuesday May 2, 2011 Poster #38

It has long been suggested that the acoustic waves would convert into other types of waves when interacting with the magnetic field Our numerical simulations of interaction of MHD waves with magnetized areas permit to reveal the details of wave propagation and transformation in various models of sunspots. The conversion occurs near the sunspot axis in the region where the wavefront of the fast MHD wave crosses the level where the plasma parameter ß is of order of unity. The transformed wave is primarily perpendicular. Detailed simulations show, that the transformed wave exists even in case where the source is located completely outside of the magnetic region, so the wave, which enters the model of the sunspot, is pure acoustic. To compare simulations of MHD waves in sunspots and observations we need to know at what geometrical depth this comparison has to be done. We propose a method of the wave amplitude and travel-time shortening corrections due to the Wilson depression, using three-dimensional numerical simulations of propagation of linear MHD waves. The main drawback of the previous simulations was inability to directly compare simulation results with the observations, because it is not clear from which height we need to take the simulated velocities to compare them with the velocities obtained from the observed Doppler shifts. The only way to solve this problem is to simulate not only the wave propagation, but the HMI measurement process as well. Our method is based on the combination of three-dimensional numerical simulations of propagation of MHD waves with radiation transfer simulations of the HMI line formation and detection of the Doppler shift and line splitting using the same set of 6 narrow-band filters which is used by the HMI instrument. Such simulations will provide the artificial HMI level 1 data (if necessary, non-simultaneity of frames for different polarization channels can be simulated) which can test the whole Time-Distance Pipeline.

Effect of Strong Meridional Flows at the Bottom of the Convection Zone on the Solar Dynamo

Author(s): V.V. Pipin(1-3) and A.G. Kosovichev(1)
Affiliation(s): (1)HEPL, Stanford University; (2)IGPP, UCLA; ISTP, Irkutsk

Monday May 2, 2011 Poster #30

Theoretical models of the angular momentum distribution predict that the return meridional flow is confined at the bottom of the convection zone, and that its speed is significantly higher than it is usually assumed in dynamo theories. We study a new class of kinematic axisymmetric

mean-field dynamo models for a case of the meridional circulation with a deep-seated stagnation point and a strong return flow at the bottom of the convection zone. We show that it is possible for this types of meridional circulation to construct the dynamo models that resemble in some aspects the sunspot magnetic activity cycle. In these models the toroidal magnetic field, which is responsible for the sunspot production, is concentrated at the bottom of the convection zone, and is transported to low-latitude regions by meridional flow. The meridional component of the poloidal field is concentrated at the bottom of the convection zone while the radial component is concentrated in near polar regions. The models have a curious property that the duration of the magnetic cycle does not always monotonically increases when the meridional flow speed decreases. For the further progress it is important to determine the deep structure of the meridional circulation, which is one of the critical properties, from the SDO/HMI helioseismology observations.

Characteristics of Solar Magnetic Cycles Predicted by a Surface-shear Dynamo Model

Author(s): V.V. Pipin(1-3) and A.G. Kosovichev(1)

Affiliation(s): (1)HEPL, Stanford University; (2)IGPP, UCLA; (3) ISTP, Irkutsk

Monday May 2, 2011 Poster #29

We present a study of solar dynamo model distributed in the bulk of the convection zone with toroidal magnetic-field flux concentrated in a near-surface layer. We explore how this effect may depend on spatial variations of the turbulent parameters and the differential rotation near the surface. The model includes the magnetic helicity non-linear feedback on the dynamo alpha-effect. We compute the magnetic cycle characteristics predicted by the model, including the cycle skewness (associated with duration of the growth and decay phases) and the duration-strength dependence (Waldmeier's effects). We confront the theoretical expectations with the solar sunspot cycle properties.

Anisotropy of Wave Parameters Near Active Regions

Author(s): M.C. Rabello-Soares(1), R.S. Bogart(1), P.H. Scherrer(1), C.S. Baldner(2), S. Basu(2), O. Burtseva(3), D.A. Haber(4), F. Hill(3), R. Howe, K. Jain(3), I. Gonzalez-Hernandez(3), R. Komm(3), S. Tripathy(3)

Affiliation(s): (1) Stanford University; (2) Yale University; (3) National Solar Observatory; (4) JILA University of Colorado

Tuesday May 3, 2011 Poster #49

The solar acoustic oscillations are affected as they propagate inside a sunspot. Here, we search for anisotropy of the wave parameters near active regions obtained from HMI data using ring-diagram analysis. The wave characteristics in magnetically quiet regions with a nearby active region are compared with those of quiet regions at the same solar disk positions, but with no nearby active regions.

Analyzing AIA Dispersion Effects in Conjunction with RHESSI and EVE Observations

Author(s): Claire Raftery, Säm Krucker

Affiliation(s): SSL, UC Berkeley

Monday May 2, 2011 2:02-2:20pm

The hydrodynamic properties of solar flares can provide us with vital information required for the complete and correct interpretation of these events. While imaging telescopes, such as AIA can provide us with unprecedented cadence and resolution, they also produce diffraction patterns during the brightest of events. Here, we analyze the diffraction patterns of e.g. the SDO/AIA 131, 171 and 193 Å passbands to more than 40 orders. Analysis of dispersion effects associated with diffraction patterns, in conjunction with imaging and spectroscopy from RHESSI gives an insight into the geometry of the flaring loop, along with the thermal distribution of plasma within the system. We will further this analysis by using spectra from SDO/EVE as a reference for the AIA dispersion patterns.

Testing and Correcting for 'Surface Seismic Signals' in Sunspot Regions Using HMI/SDO Filtergrams

Author(s): S.P. Rajaguru(1) and S. Couvidat(2)

Affiliation(s): (1) Indian Institute of Astrophysics, Bangalore, India; (2) HEPL, Stanford University, Stanford CA, USA

Tuesday May 3, 2011 Poster #44

It has recently been observationally verified (Rajaguru *et al*. 2010 ApJL, 721, L86) using imaging spectropolarimetry that magnetically modified wave propagation in the formation layers of FeI 6173 A introduce seismic signals that depend sensitively on observation height and hence on which portion of the line is used in deriving Doppler velocities. Availability of HMI filtergrams obtained over 6 positions each over the left and right circular polarization profiles of the above line provide a way of testing for the above signals and accounting for them before performing helioseismic inversions for inferences on the subsurface layers. We first experiment with obtaining Dopplergrams with pairs of filtergrams that sample the wings, and those that sample the cores of the LCP and RCP profiles observed over the sunspot region in NOAA AR 11092. We then perform helioseismic travel time measurements and estimate the contributions from within the line forming layers. We also differentiate such contributions in the in- and out-going travel times, which helps us estimate the apparent flow signals and some properties of acoustic wave sources beneath the sunspot.

On the Role of Coronal Jets as a Driver of Plumes

Author(s): Nour-Eddine Raouafi

Affiliation(s): Johns Hopkins University Applied Physics Laboratory

Tuesday May 3, 2011 Poster #62

We use observations from the SDO/AIA and Hinode/XRT to investigate the role of coronal jets in driving the formation and evolution of coronal plumes. We focus particularly on the relation between jets and long-lived plumes and the role of short-lived, jet-like events in driving plumes variability. This is achieved via a statistical study using high cadence observations of SDO/AIA.

On the Structure of Bright Points Sources of Coronal Jets

Author(s): Nour-Eddine Raouafi

Affiliation(s): Johns Hopkins University Applied Physics Laboratory

Tuesday May 3, 2011 Poster #63

Observations from the SDO/AIA and Hinode/XRT are used to study the nature of coronal bright points leading to eruptions of coronal jets. We investigate particularly the occurrence of small-scale sigmoids at the footpoints of coronal jets and whether these structures are the source of the unwinding motions observed in jets.

Exploring Sunspot Atmospheric Oscillations with SDO and IBIS

Author(s): Reardon, K. (1,2)

Affiliation(s): (1) INAF - Arcetri Astrophysical Observatory, Florence, Italy. (2) Queen's University Belfast, Belfast, NI, UK

Tuesday May 3, 2011 Poster #58

We combine imaging spectroscopy observations of AR 11093 made on August 10, 2010 from the Interferometric Bidimensional Spectrometer (IBIS) with simultaneous AIA and HMI data in order to study sunspot oscillations in different regions of the solar atmosphere. With IBIS we observed the Fe I 6173 and Ca II 8542 spectral lines over a 95 arcsecond field of view with an 11 second cadence, comparable to that achieved with AIA. We compare the parameters extracted from the full 6173 spectra from IBIS with those obtained by HMI. With the Ca II 8542 line we observe the details of the sunspot dynamics in the chromosphere, and examine their relationship with the coronal behavior above the active region seen by AIA. We discuss the fine-scale structure of the umbral oscillations seen at high resolution.

Flux Emergence of the Active Region: The First 8 Hours

Author(s): S. Regnier

Affiliation(s): University of Central Lancashire

Tuesday May 3, 2011 10:00-10:18am

In Feb. 2010, the Solar Dynamics Observatory (SDO) was launched. SDO is dedicated to the study of the Sun's magnetic activity and the associated coronal responses. Using the combination of observations provided by both the imager SDO/AIA (5 wavelengths at 45s cadence) and the magnetograph SDO/HMI (line-of-sight magnetograms at 45s cadence), we study the emergence of a peculiar active region from the photosphere to the million degree corona. Focusing on the first 8 hours of the emergence stage until the creation of a pore, we show that the active region emerges near the boundary of a supergranular cell and does not evidence any rotational motions contrary to models of emerging twisted flux tubes. The mass loading into the corona and the ubiquitous presence of flows are highlighted by the coronal observations from 50000K to 2 MK. We also evidence the thermal structure of the emerging active region (thermal shielding) as well as the interaction between the emerged magnetic field and the pre-existing coronal field through successive reconnection. We compare this evolution to numerical models of flux emergence.

A Large Polar-crown Filament Eruption Observed by SDO/AIA and STEREO-A/EUVI

Author(s): S. Regnier, C. E. Alexander, and R. W. Walsh

Affiliation(s): University of Central Lancashire

Wednesday May 4, 2011 Poster #111

Using the two points-of-view of SDO/AIA and STEREO-A/EUVI (about 70 degrees apart), we observed a large-scale polar crown filament eruption on 13 June 2010 in the Northern hemisphere. Comparing the plasma at 80000 K and at 0.6 MK, we deduce the structure of the filament/prominence and its evolution. The polar-crown is composed of hot and cool plasma sitting at the bottom of a cavity in upwardly concave magnetic field lines. We also study the different possible initiation processes leading to the eruption by looking at local and global events which can destabilise the filament such as weak filament activity in a nearby active region, a flare and the associated CME wave starting in the Southern hemisphere, existence of a trans-equatorial loop, instability of the filament (kink, torus, mass loading). We discuss the contribution and timing of each initiation process to the filament eruption: the mass loading scenario and the CME wave seem to be the more likely mechanisms.

3-min Oscillations over Sunspot: SDO and NoRH Data Analysis

Author(s): V. Reznikova(1), K. Shibasaki(1), V. Nakariakov(2), R. Sych(3)

Affiliation(s): (1) Nobeyama Solar Radio Observatory, NAOJ, Japan; (2) Physics Department, University of Warwick, Coventry, CV4 7AL, UK; (3) Institute of solar-terrestrial physics SB RAS, Irkutsk, Russia

Monday May 2, 2011 Poster #20

We study 3-min oscillations over sunspot's umbra in AR 11131 using 24-hours series SDO/AIA and 8-hours series of Nobeyama Radioheliograph (NoRH) observations. Spectral, spatial and temporal variations of pulsations in 5-7 mHz band at different heights of solar atmosphere are analyzed. Discovered tendencies are discussed in terms of the acoustic cutoff frequency variations.

Magnetic Element Meridional Flow: Dependence on Strength

Author(s): Lisa A. Rightmire(1), David H. Hathaway(2)

Affiliation(s): (1) University of Alabama Huntsville; (2) NASA MSFC

Monday May 2, 2011 10:36-10:54am

Meridional Flow (MF) speeds are only on the order of 10-20 m/s. For this reason, MF is the most difficult transport velocity to measure. However, these velocities can be measured by tracking the motion of small magnetic elements on the surface of the sun and averaging over a Carrington Rotation (CR). Magnetograms obtained by the HMI instrument aboard SDO are turned into maps of the magnetic features. Strips from these maps, taken 8 hours apart, are then cross-correlated to determine the distances in latitude and longitude that flux elements have moved, thus producing MF and differential rotation velocities as functions of latitude. Averaging the MFs obtained for every 8 hour separation over a 27-day CR produces a MF profile for that CR. This process was repeated for data with varying magnetic element strength. Results show that the MF is more complex than previously thought. It varies with the strength of the magnetic elements. The MF is slower for the stronger flux elements. This is consistent with stronger flux elements being anchored deeper in the Sun's surface shear layer where the MF is slower. New Surface Flux Transport and Solar Dynamo models should reproduce solar conditions while including these variations.

The Evolution of Dark Canopies Around Active Regions

Author(s): E. Robbrecht, Y.-M. Wang, K. Muglach

Affiliation(s): Royal Observatory of Belgium

Tuesday May 3, 2011 10:36-10:54am

As observed in spectral lines originating from the chromosphere, transition region, and low corona, active regions are surrounded by an extensive "circumfacular" area which is darker than the quiet Sun. The dark areas are most clearly observed in the AIA 17.1 nm and 13.1 nm images. In this study we examined the origin and properties of these dark moat- or canopy-like areas using Fe IX 17.1 nm images and line-of-sight magnetograms from the *Solar Dynamics Observatory*. Careful observations showed that these dark features seen in Fe IX represent chromospheric material, organized in horizontal fluxtubes connecting photospheric flux elements of opposite polarity. In emerging active regions the flux balloons outward in a dipole-like configuration. As a consequence, through reconnection with the background network, a pattern of dark fibrils is formed, diverging from the area occupied by strong plage. The diffusing fibrils gradually accumulate around large-scale polarity inversion lines. Systematic flux cancellation at the PIL results in the removal of the transverse component and the formation of proto-filaments and filaments. (This paper is accepted for publication in *ApJ,* Wang, Robbrecht & Muglach, 2011.)

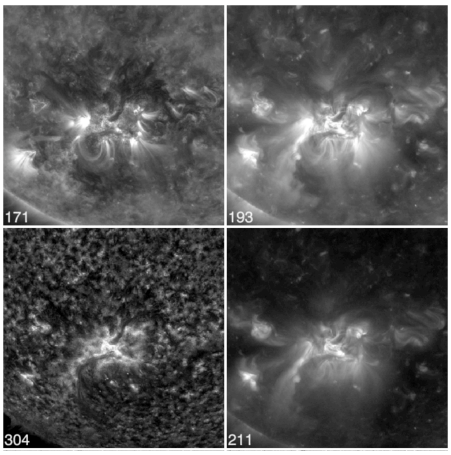

Figure Caption: AIA images from the Solar Dynamics Observatory, showing a "dark canopy" surrounding an active region.

The Temperature-dependent Nature of Coronal Dimmings

Author(s): E. Robbrecht & Y.-M. Wang

Affiliation(s): Royal Observatory of Belgium

Wednesday May 4, 2011 Poster #94

The opening-up of the magnetic field during solar eruptive events is often accompanied by a dimming of the local coronal emission. From observations of filament eruptions recorded with the Extreme-Ultraviolet Imager on STEREO during 2008–2009, it is evident that these dimmings are much more pronounced in 19.5 nm than in the lower-temperature line 17.1 nm, as viewed either on the disk or above the limb. We conclude that most of the cooler coronal plasma is not ejected but remains gravitationally bound when the loops open up. This result is consistent with Doppler measurements by Imada and coworkers, who found that the upflow speeds in a transient coronal hole increased dramatically above a temperature of 1 MK; it is also consistent with the quasistatic behavior of polar plumes, as compared with the hotter interplume regions that are the main source of the fast solar wind. When the open flux reconnects and closes down again, the trapped plasma is initially heated to such high temperatures that it is no longer visible at Fe ix 17.1 nm. Correspondingly, 17.1 nm images

show a dark ribbon or "heat wave" propagating away from the polarity inversion line and coinciding with the brightened Fe xv 28.4 nm and Fe xii 19.5 nm post-eruptive loops and their footpoint areas. Such dark ribbons provide a clear example of dimmings that are not caused by a density depletion. The propagation of the "heat wave" is driven by the closing-down, not the opening-up, of the flux and can be observed both off-limb and on-disk.

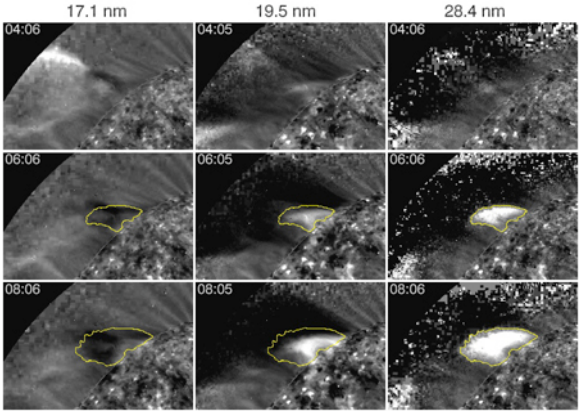

Figure Caption: Eruption of a filament at the northeast limb on 2009 January 14, as viewed from STEREO/EUVI A. The images show the ratio of the local brightness at the indicated time relative to a base image taken at 19:06 UT on January 13, for each of the emission lines Fe ix 17.1 nm (left column), Fe xii 19.5 nm (middle column), and Fe xv 28.4 nm (right column). In the two hotter lines (19.5 and 28.4 nm), the dimming appears as a dark void above the limb; this void is not seen in the cooler 17.1 nm bandpass. The 17.1 nm images at 06:06 and 08:06 UT show dark features that coincide with the outer edges (indicated by the yellow contours) of the bright post-eruptive loops in 28.4 nm.

Using SDO Data in the Classroom

Author(s): Deborah Scherrer(1), Tim Dave (2), Scott Hildreth(2)

Affiliation(s): (1)Stanford University; (2) Chabot Community College

Tuesday May 3, 2011 Poster #74

The Education and Pubic Outreach (EPO) team for NASA's Solar Dynamics Observatory is attempting to find ways to bring SDO data into K-14 classrooms in a meaningful and stimulating way. It is well-known that students who have opportunities to work with real scientific data and research are much more successful in future science courses and more likely to enter STEM careers. The Stanford Solar Center, in conjunction with Chabot Community College, Hayward, CA is undertaking an experiment to develop and test a laboratory activity based on data from SDO and appropriate to community college physics and astronomy classes. Our poster describes the environment for this experiment, the key players, our process, and details a potential activity based on rotation of solar sunspots. Should the experiment be successful, the lab will tried in other diverse environments and potentially enhanced for use in high schools.

Diagnosing the Prominence-Cavity Connection

Author(s): Donald Schmit, Sarah Gibson, Theresa Kucera
Affiliation(s): University of Colorado, High Altitude Observatory, NASA Goddard Space Flight Center

Wednesday May 4, 2011 Poster #102

Prominences are regions of cool, condensed plasma suspended in the corona. Cavities are regions of rarefied density surrounding the off-limb prominence. Despite the frequency with which structures are observed together, there is little evidence of the structural and energetic connection between them. We use the fact that the cavity and prominence exhibit strong variability in EUV emission as a tool to extract substructure from within the cavity. In particular, we seek to address the degree to which the magnetic field thermodynamically links the condensed prominence and the hotter cavity material. The morphology of the extracted observational substructures will be compared with numerical MHD models of prominence support. We are now examining the models in order to access the quantitative and observationally-constraining properties with which we may access model validity.

The 2011/02/15 X2 Flare, Ribbons, Coronal Wave, and Mass Ejection: Interpreting the 3-D Views from SDO and STEREO Guided by MHD Flux-Rope Modeling

Author(s): C.J. Schrijver(1), G. Aulanier(2), A.M. Title(1), E. Pariat(2), and C. Delannée(2)

Affiliation(s): (1) Lockheed Martin Advanced Technology Center; (2) Observatoire de Paris, Meudon

Wednesday May 4, 2011 1:26-1:44pm

The 2011/02/15 X2.2 flare and associated Earth-directed halo coronal mass ejection were observed in unprecedented detail with high resolution in spatial, temporal, and thermal dimensions by the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory, as well as by instruments on the two STEREO spacecraft, then at near-quadrature relative to the Sun-Earth line. These observations enable us to see expanding loops from a flux-rope like structure over the shearing polarity-inversion line between the central delta-spot groups of AR11158, developing a propagating coronal front ("EIT wave"), and eventually forming the CME moving into the inner heliosphere. The observations support the interpretation that all of these features, including the "EIT wave" are signatures of an expanding volume traced by loops (much larger than the flux rope only), surrounded by a moving front rather than predominantly wave-like perturbations; this interpretation is supported by previously-published MHD models for active-region and global scales. The lateral expansion of the eruption is limited to the local helmet-streamer structure and halts at the edges of a large-scale domain of connectivity (in the process exciting loop oscillations at the edge of the southern polar coronal hole). The AIA observations reveal that plasma warming occurs within the expansion front as it propagates

over quiet Sun areas. This warming causes dimming in the 171Å (Fe IX & X) channel and brightening in the 193 and 211Å (Fe XII-XIV) channels along the entire front, while there is weak 131Å (Fe VII & XXI) emission in some directions. Analysis of the AIA response functions shows sections of the front running over quiet Sun are consistent with adiabatic warming; other sections may require additional heating which, according to the MHD modeling, could be caused by Joule dissipation. Whereas for the events studied here the effects of volumetric expansion are much more obvious than true wave phenomena, we discuss how different magnetic environments within and around the erupting region can lead to to the signatures of either or both of these aspects.

Tracking Vector Magnetograms from the Solar Dynamics Observatory

Author(s): P.W. Schuck(1), X. Sun(2), K. Muglach(3), J.T. Hoeksema(2)

Affiliation(s): (1) NASA/GSFC; (2) Stanford University; (3) Artep, Inc.

Wednesday May 4, 2011 Poster #128

The differential affine velocity estimator for vector magnetograms (DAVE4VM) has been developed for estimating photospheric velocities. The accuracy of this technique has been demonstrated on synthetic magnetograms from MHD simulations. The algorithm was initially formulated in Cartesian coordinates. Thus, for best results, solar vector magnetograms must be transformed from the image plane into a Mercator map or some other Cartesian-like projection before applyng DAVE4VM. Recently, DAVE4VM has been modified to incorporate directly the projected spherical geometry of Helioprojective-Cartesian coordinates, thus permitting direct application of the method to image plane vector magnetograms. We will discuss the new algorithm and tests of the modified method and present first results of DAVE4VM applied to Solar Dynamics Observatory vector magnetograms.

Understanding the Helioseismic Signature of Sunspots

Author(s): H. Schunker, R.H. Cameron, L. Gizon & H. Moradi

Affiliation(s): Max Planck Institut fuer Sonnensystemforschung

Tuesday May 3, 2011 1:26-1:44pm

Recent studies have revealed a significant disagreement between different helioseismic analysis methods of the inferred structure below the sunspot of AR9787. To understand the helioseismic effects of a sunspot, we have used numerical simulations of linear wave propagation through semi-empirical sunspot models. We present a model that reproduces most of the observed helioseismic signal. We also present simulations that demonstrate the seismic signature due to localised changes in subsurface sunspot structure.

Joint AIA-SWAP Observations of Reconnection-Related Processes During Coronal Eruptions

Author(s): Dan Seaton(1), Elke D'Huys(1), Kathy Reeves(2), Terry Forbes(3), Sabrina Savage(4)

Affiliation(s): (1) Royal Observatory of Belgium; (2) Harvard-Smithsonian Center for Astrophysics; (3) UNH; (4) NASA Goddard Space Flight Center

Wednesday May 4, 2011 10:54-11:12am

Magnetic reconnection is widely regarded as the driver for energy release during eruptions in the solar corona. Several different models of eruptions offer explanations of how this stored magnetic energy in the corona can be converted into kinetic and thermal energy during an eruption, leading to observable phenomena like solar flares and coronal mass ejections. Because of their high spatial and temporal resolution and wide temperature coverage, observations from AIA are especially well suited to test these models. However, AIA's relatively limited field of view means that the region where the actual reconnection occurs is often not captured in AIA images. So PROBA2's SWAP EUV Imager, which has a larger field of view and off-pointing capabilities that make it possible to capture the more extended EUV corona, provides an excellent companion instrument for analysis of eruptive events. Here we present some combined observations of one such eruption, on 12 January 2011, using both SWAP and AIA and discuss observational implications for models of eruption mechanisms.

Helioseismic/magnetic Measurements of the Sun from a Highly Inclined Solar Orbit

Author(s): T. Sekii(1), T. Appourchaux(2), S. Brun(3), W. Finsterle(4), L. Gizon(5), H. Hara(1), T. Hartlep(6), F. Hill(7), H. Isobe(8), A.G. Kosovichev(6), J. Leibacher(7), M. Miesch(9), M. Rempel(9), S. Tsuneta(1), T. Yokoyama(10), J. Zhao(6)

Affiliation(s): (1)NAOJ (2)IAS (3)CEA Saclay (4)PMOD/WRC (5)MPS (6)Stanford University (7)NSO (8)University of Kyoto (9)HAO/NCAR (10)University of Tokyo

Monday May 2, 2011 Poster #9

We discuss as a future mission concept a spacecraft in a highly inclined orbit around the Sun, equipped with an HMI-like Doppler and magnetic imager as the main instrument, and a suite of instruments such as an X/EUV telescope, an EUV imaging spectrometer, and a total solar irradiance monitor. The inclination angle should be 40 degree or greater, to ensure long observation time above the solar mid-latitudes. Such a mission will enable us to study various flows and activity phenomena in high-latitude regions of the Sun, to help us advance our knowledge on the mechanism of the solar magnetic variability.

Correcting Stray Light in EUV Images

Author(s): Paul Shearer, Rich Frazin
Affiliation(s): University of Michigan

Wednesday May 4, 2011 Poster #121

EUV images are contaminated by stray light caused by mirror microroughness and diffraction effects. The contamination is worst in faint regions, such as coronal holes and filament cavities. For example, in the Extreme Ultraviolet Imager (EUVI) on STEREO, we have determined that up to 60% of the apparent emissions from these regions are stray light. In the off-limb, the problem is far worse; it is easy to see from lunar transit images (taken by EUVI-B on 2/25/07) that stray light often completely overwhelms the actual off-limb emissions. We expect that AIA suffers from similar problems due to the similar optical design. Indeed, diffraction effects can already be seen in the AIA flare movies. To remove stray light, the Point Spread Functions (PSFs) of EUV instruments must be estimated in each band, a difficult signal processing problem known as blind deconvolution. The possibilities for success are greatly enhanced by the lunar transit in EUVI-B. We will present our current efforts to estimate the PSFs and deconvolved images for EUVI and how our experience can be transferred to to AIA.

A Study of Flare Kernels Using SDO Imagery

Author(s): Gregory Slater, Samuel Freeland
Affiliation(s): Lockheed Martin Solar and Astrophysics Laboratory

Wednesday May 4, 2011 Poster #86

The high time and spatial resolution of SDO imagery makes it possible to study the distribution and evolution of activity and flare kernels within active regions. We will systematically extract emission kernels from AIA imagery during flares of various magnitudes to study the morphology and temporal evolution of the flare kernels. We will compare these emission kernels with changes in the local photospheric magnetic field from HMI magnetograms and changes in the coronal magnetic field configuration as revealed by AIA images to address the question of whether the positions and spatial development of flare kernels are determined more by the configuration of emerging flux from the convective zone or by the configuration of the coronal field. We will extract flare kernel histories algorithmically from AIA imagery and compare to HMI magnetogram data. A database of flare kernel histories will be created.

AIA Observations of Sunspot Waves

Author(s): Elie Soubrié(1), Frédéric Auchère(1), Frédéric Baudin(1), John Leibacher(1,2)
Affiliation(s): (1) Institut d'Astrophysique Spatiale, Orsay, France; (2) National Solar Observatory, Tucson, Arizona, USA

Tuesday May 3, 2011 Poster #60

Waves in the low solar atmosphere above sunspots *i)* present an interesting phenomenon in their own right, *ii)* are potentially a probe of magnetic structures (e.g. "plumes") in the sunspot atmosphere and a source of excitation of higher, coronal loop waves, and *iii)* are coupled to umbral flashes and sub-surface, helioseismic waves in a manner that is not fully understood. We present an analysis of AIA observations of waves in AR 11092, showing their propagation, temporal coherence, and angular symmetry; characterizing them in terms of frequency, amplitude, and propagation speed.

The Altitude Dependence of the Earth's Ionosphere on the Solar Extreme Ultraviolet Spectrum

Author(s): J. J. Sojka, R. W. Schunk, and M. David
Affiliation(s): Utah State University

Wednesday May 4, 2011 9:00-9:30am

The dayside ionospheric plasma is generated by solar photons in the soft-x-ray and extreme ultraviolet spectrum. These photons have strong wavelength dependences for both their ionization and absorption cross sections in the Earth's atmosphere. This leads to a wavelength dependence on how these photons contribute to the altitude distribution of the ionosphere. Two ionospheric layers, the E and F, will be contrasted to demonstrate their relative dependence on the solar spectrum. In addition, these two layers have quite different time constants for the production and decay of the plasma. The lower E-region, at about 100 km, has production and recombination times of much less than a minute. The F-region peak, where diffusion is also important, has time constants much larger than a minute. Therefore, the dayside ionosphere will have quite different temporal responses to solar flares whose rise-time would be characterized as less than a minute. Furthermore, the recent Solar Dynamics Observatory (SDO) Extreme Ultraviolet Variability Experiment (EVE) has shown that during flares, the emission lines also exhibit a complex wavelength temporal behavior. The E- and F-region consequences of rapid onset (faster than a minute) and emission delays (on the order of minutes) of the solar spectrum will be presented. The 15 February 2011 SDO-EVE observations of the X2.2 class flare will be used as the flare reference for this study.

SDO-based Targeting Tools for the New Multiline Spectrometer at the Vacuum Tower Telescope (VTT), Tenerife.

Author(s): Joachim Staiger
Affiliation(s): Kiepenheuer-Institut, Freiburg

Monday May 2, 2011 Poster #5

We are currently developing a Fabry Perot-based 2D-Spectrometer with the primary goal of increasing the number of available wavelength bands for ground-based observations. During a test run of several hours duration we were able to record 16 spectral lines in a quasi-simultaneous mode at a cadence of 60 seconds. The new instrument will be used for investigating wave propagation and mode conversion in a magnetically active atmosphere and for analyzing photospheric footprints of coronal loops. Both research fields can be expected to benefit strongly from the availability and easy accessibility of near-realtime high-quality SDO data. For the purpose of easy-to-use targeting of magnetic patterns and loop structures we have upgraded the telescope control software of the VTT in order to continuously download the most recent HMI/AIA data products from NASA/SDO websites. After applying automatic scaling and shifting operations and correcting for differential rotational pattern propagation since the moment of image capture these data become accessible from the VTT control surfaces. The telescope may then be directed towards regions-of-interest just by mouse-click. 12 SDO data channels are available for target selection. We plan to prepare a simulated multiline observation with this basic prototype of space-based/ground-based telescope synchronization for demonstration purposes.

Magnetic Flux Emergence Simulations and Pore Formation

Author(s): Robert F. Stein(1), Åke Nordlund(2), Dali Georgobiani(1)

Affiliation(s): (1) Michigan State University, East Lansing, MI, USA; (2) Niels Bohr Institutute, Copenhagen, DK

Tuesday May 3, 2011 12:50-1:08pm

We report on simulations of emerging, minimally structured (uniform, untwisted, horizontal) magnetic field from a depth of 20 Mm in a domain 48 Mm wide. The inflow field strength was slowly increased from 200 G to 5 kG with an e-folding time of 5 hours. The field emerges first in a mixed polarity "pepper and salt pattern", but then collects into separate, unipolar concentrations. After 19 hours a pore spontaneously forms. The magnetic concentration in the pore first forms near the surface at the edge of a large rising magnetic loop. As time goes in it extends downward and accumulates more magnetic flux. After another 7 hours it has an grown to an area somewhat larger than 3 Mm^2 and it has accumulated a magnetic flux of 3x10^17 Mx. The vertical field, at continuum optical depth 0.1, has a power law distribution with a slope of -1.35, with a little excess around 1.8 kG and the pore a little blip in the distribution between 2.1 and 2.8 kG. The minimum intensity in the pore is 20% of the average intensity and there are bright points in other locations of strong field with intensities 1.5-2.5 times the mean intensity. After 26 hours since the field started rising from the bottom (typical fluid rise time is 32 hours), the large scale loops from the large depths have not yet reached the surface, so buoyancy effects are small in this case. A proto-active region was produced in another simulation by artificially increasing the magnetic field strength everywhere after several pores had formed. The pores grow in size with only small increases in magnetic field strength (as the Wilson depression gets deeper) and form some penumbral-like features. One of the spot like structures where the field was weaker gets filled in over time with a swirling motion of the inflowing plasma. We will present some results from this case also. Slices of the velocity and magnetic field vectors at continuum optical depths of 1, 0.1, and 0.01 and the emergent intensity have been saved at 1 minute intervals. 4 hour averages, with 2 hour cadence for the 3D cube for variables: velocity, magnetic field, density, temperature, sound speed, and internal energy have been computed. Stokes spectra have been computed for the Hinode FeI 630 nm lines, processed with the Hinode annular mtf, the slit diffraction and frequency smoothing. These data are all available at steinr.pa.msu.edu/~bob/data.html. This work has been supported by NASA grants NNX07AO71G, NNX07AH79G and NNX08AH44G and NSF grant AST0605738. The simulations where performed on the pleiades cluster of the NASA Advanced Supercomputing Division at the Ames Research Center.

Observations and Magnetic Field Modeling of the Flare/CME Event on 2010 April 8

Author(s): Yingna Su, Vincent Surges, Adriaan van Ballegooijen, Edward DeLuca, Leon Golub

Affiliation(s): Smithsonian Astrophysical Observatory

Wednesday May 4, 2011 Poster #99

We present a study of the flare/CME event that occurred in Active Region 11060 on 2010 April 8. This event also involves a filament eruption, EIT wave, and coronal dimming. Prior to the flare onset and filament eruption, both SDO/AIA and STEREO/EUVI observe a nearly horizontal filament ejection along the internal polarity inversion line, where flux cancellations frequently occur as observed by SDO/HMI. Using the flux-rope insertion method developed by van Ballegooijen (2004), we construct a grid of magnetic field models using two magneto-frictional relaxation methods. We find that the poloidal flux is significantly reduced during the relaxation process, though one relaxation method preserves the poloidal flux better than the other. The best-fit pre-flare NLFFF model is constrained by matching the coronal loops observed by SDO/AIA and Hinode/XRT. We find that the axial flux in this model is very close to the threshold of instability. For the model that becomes unstable due to an increase of axial flux, the reconnected field lines below the X-point closely match the observed highly sheared flare loops at the event onset. The footpoints of the erupting flux rope are located around the coronal dimming regions. Both observational and modeling results support the premise that this event may be initiated by catastrophic loss-of-equilibrium caused by an increase of axial flux in the flux rope, which is driven by flux cancellations.

Structure and Dynamics of the Quiescent Prominence Eruption on 2010 December 6

Author(s): Yingna Su, Adriaan van Ballegooijen
Affiliation(s): Harvard-Smithsonian Center for Astrophysics

Wednesday May 4, 2011 Poster #100

We present observations of the quiescent prominence that erupted on 2010 December 6. This prominence contains two parts: one part located in the active region remnant contains mainly horizontal threads, and another part located in the quiet Sun contains mainly vertical threads. Combination of SDO/AIA and STEREO/SECCHI/EUVI allows us to see the fine structures of this prominence both at the limb and on the disk. Halpha observations from KSO are also included. We focus on the fine structures and dynamics of this prominence before, during, and after the eruption. Prior to the eruption, STEREO shows that filament material frequently ejects horizontally from the active region part to the quiet Sun part. This ejection results in the formation of a tree-like structure (concentration of dark vertical threads) near the border between the active region remnants and the quiet Sun. Around 14:18 UT, brightenings appeared around the filament in the active region remnants, which was followed by the lifting off of the filament starting from the center of the active region remnant. Most parts of the filament erupted except a small fraction near the quiet Sun end. The filament left behind shows vertical threads in SDO/AIA at the east limb, but a thin dark filament on the disk is observed by STEREO/EUVI.

Evolution of Magnetic Field in the Flaring Active Region 11158 Observed by SDO/HMI

Author(s): Xudong Sun(1), Todd Hoeksema(1), Yang Liu(1), Thomas Wiegelmann(2), Keiji Hayashi(1)
Affiliation(s): (1) Stanford University; (2) MPI

Wednesday May 4, 2011 11:12-11:30am

We report the evolution of the magnetic field in NOAA AR11158 over 5 days (2011 Feb 12-16), using vector magnetograms from the Helioseismic and Magnetic Imager (HMI) aboard the Solar Dynamic Observatory (SDO). This region displayed a complex quadrupolar field topology and produced multiple major flares and eruptions, including the first X-class flare of the current solar cycle. Strong shear motion and flux emergence were both present, with apparent emergence preceding each major flare by less than one day. We reconstruct the coronal field from a series of vector data using a non-linear force-free (NLFF) extrapolation. The estimated free magnetic energy shows a great increase during the early emergence of the current-carrying flux, while a significant, permanent decrease (~.5e32 erg, or 20%) is found after the X-class flare despite continuous flux injection. We relate this decrease to a previously reported, sudden change of photospheric field after the flare. The coronal field structure correspondingly becomes more "compact": low-lying field appears more sheared and stores more free energy, and higher-altitude field decays faster with height and becomes more potential. The coronal field overall becomes less-energetic.

Validated Helioseismic Inversions for 3-D Vector Flows: Applications to SDO Data

Author(s): M. Svanda, L. Gizon, S.M. Hanasoge, and S.D. Ustyugov
Affiliation(s): Max-Planck-Institut fuer Sonnensystemforschung

Monday May 2, 2011 10:54-11:12am

We improved and validated travel-time inversions for 3-D vector flows. The main improvement comes from the explicit minimization of the cross-talk between the three flow components. The validation was performed using synthetic travel-time maps obtained by convolving a known flow field from a realistic numerical simulation of solar convection with travel-time sensitivity kernels computed in the Born approximation. Realistic noise is added to the travel times. The inversion of synthetic travel-times returns unbiased answers for horizontal flow velocities in layers shallower than 4 Mm. We also show that the vertical component of velocity near the surface can only be inferred under the explicit condition that the cross-talk between the flow components is minimized. A preliminary application to SDO/HMI quiet-Sun data is presented.

The Role of the Photospheric Field in the Formation of Chromospheric Spicules

Author(s): T. Tarbell, B. De Pontieu, L. Rouppe van der Voort, D. Sekse, A. Sainz-Dalda, J. Martínez-Sykora, V. Hansteen, S. McIntosh, M. Carlsson, T. Pereira
Affiliation(s): LMSAL (*et al.*)

Wednesday May 4, 2011 Poster #79

Fast moving, so-called "type II spicules" have recently been implicated in providing the corona with hot plasma. However, we do not understand how they form, and what role the magnetic field plays in driving these supersonic jets into the corona. The recent discovery of so-called rapid blue shifted events (RBEs), the disk counterpart of type II spicules, allows us to study in detail the magnetic field configuration at the root of these jets. We use a one hour long timeseries of H-alpha 6563Å and Ca II 8542Å images obtained with the CRISP instrument at the Swedish Solar Telescope (SST) in La Palma, Spain to identify the rapid chromospheric upflows. To determine whether the photospheric field configuration at the roots of spicules can provide insight into the formation mechanism of spicules, we analyze the vector magnetic field at the spicule roots using data from the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO), as well as fast raster scans from the SpectroPolarimeter (SP) onboard Hinode. We compare these with synthetic

observations from 3D radiative MHD simulations using the Bifrost code.

Calculating Energy Storage Due to Topological Changes in Emerging Active Region NOAA AR11112

Author(s): Lucas Tarr and Dana Longcope
Affiliation(s): Montana State University

Tuesday May 3, 2011 11:30-11:48am

The Minimum Current Corona (MCC) model provides a way to estimate stored coronal energy using the number of field lines connecting regions of positive and negative photospheric flux. This information is quantified by the net flux connecting pairs of opposing regions in a connectivity matrix. Changes in the coronal magnetic field, due processes such as magnetic reconnection, manifest themselves as changes in the connectivity matrix. However, the connectivity matrix will also change when sources emerge or submerge through the photosphere, as often happens in active regions. We have developed an algorithm to estimate the changes in flux due to emergence and submergence of magnetic flux sources. These estimated changes must be removed in order to quantify storage and release of magnetic energy in the corona. To perform this calculation over extended periods of time, we must additionally have a consistently labeled connectivity matrix over the entire observational timespan. We have therefore developed an automated tracking algorithm to generate a consistent connectivity matrix as the photospheric source regions evolve over time. We have applied this method to HMI magnetograms of NOAA Active Region 11112, which underwent a GOES M--2.9 class flare around 19:00 on Oct. 16, 2010, and calculated a free magnetic energy buildup of 10^30 ergs over 3 days.

Testing Coronal Plasma Diagnostics Using 3D MHD Models of the Solar Atmosphere

Author(s): Paola Testa(1), Juan Martínez-Sykora(2,3), Viggo Hansteen(3), Bart De Pontieu(2), Mats Carlsson(3)
Affiliation(s): (1) Harvard-Smithsonian Center for Astrophysics; (2) Lockheed Martin Solar & Astrophysics Lab; (3) Institute of theoretical astrophysics, University of Oslo

Tuesday May 3, 2011 Poster #64

We synthesize coronal images and spectra from realistic 3D radiative MHD simulations obtained from the state-of-the-art Bifrost code, and explore how well they reproduce coronal observations with SDO/AIA and Hinode/EIS. We apply standard diagnostic techniques (e.g., density, temperature, abundance diagnostics) to the synthetic observations and investigate how accurately the derived physical information matches the plasma parameters of the model. We discuss the limitations of the diagnostics and their implications, also in light of the parameters of the models.

Observation of High-speed Outflow on Plume-like Structures of the Quiet Sun and Coronal Holes with SDO/AIA

Author(s): Hui Tian(1), Scott W. McIntosh(1), Shadia Rifal Habbal(2), Jiansen He(3)
Affiliation(s): (1) High Altitude Observatory, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307; htian@ucar.edu; mscott@ucar.edu; (2) Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822; (3) School of Earth and Space Sciences, Peking University, 100871 Beijing, China

Tuesday May 3, 2011 Poster #39

Observations from the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) reveal ubiquitous episodic outflows with an average speed around 130 km/s at temperatures often exceeding a million degree on plume-like structures, rooted in magnetized regions of the quiet solar atmosphere. These outflows are not restricted to the well-known plumes visible in polar coronal holes, but are also present in plume-like structures originating from equatorial coronal holes and quiet-Sun regions. Outflows are also visible in the "inter-plume" regions throughout the atmosphere. Furthermore, the structures traced out by these flows in both plume and inter-plume regions continually exhibit transverse (Alfvenic) motion. Our finding suggests that high-speed outflows exist in the magnetic network of the quiet Sun and coronal holes, and that the plume flows observed are highlighted by the denser plasma contained therein. These outflows might be an efficient means to provide heated mass into the corona and serve as an important source of mass supply to the solar wind. In higher latitude regions we demonstrate that these plume flows, clearly visible against the foreground quiet Sun, significantly contaminate the spectroscopic observations of polar coronal holes - greatly affecting the Doppler shifts observed, thus potentially impacting significant investigations of such regions.

Local and Global Field Effects

Author(s): A.M. Title and K. Schrijver
Affiliation(s): LM ATC

Wednesday May 4, 2011 10:00-10:18am

One of the most interesting observations allowed by SDO and STEREO missions operating together is the coupled behavior of flares and CME's over large fractions of the solar disk. These observations strongly suggest at least some flares and CME's are triggered by large scale restructuring of the global solar field. The events of August 1-2 have provided clear evidence of coupled flares and CME's that were associated with a flux emergence in a region beyond the west limb. Here we show multiple examples of similar couplings that can cover 180 degree or more of the disk.

SDO Data Drives Space Weather Operations

Author(s): W. Kent Tobiska, S. Dave Bouwer, Justin Bailey, and Jean Yoshii
Affiliation(s): Space Environment Technologies

Monday May 2, 2011 4:52-5:10pm

Space weather operational systems are used to provide real-time and forecast information to space- and ground-system users. These systems handle the risks from adverse space weather due to solar photons, particles, and fields as they dynamically interact with the near Earth space environment and our technological systems. Operational space weather is becoming a supply chain, where raw data is processed into geophysical information, and that in turn is used by models and algorithms to help avoid Low Earth Orbit satellite collisions with space debris, for example. We described how SDO data from the AIA, HMI, and EVE instruments are used at the front of this supply chain for applications in space and ground systems.

Local Helioseismology of Sunspot Regions: Comparison between NOAA active regions 11092 and 11093

Author(s): S. C. Tripathy(1), K. Jain(1), B. Ravindra(2), C. S. Baldner(3), S. Basu(3), R. S. Bogart(4), D. A. Haber(5), F. Hill(1), I. Gonzalez Hernandez(1), R. Komm(1), and M. C. Rabello-Soares(4)
Affiliation(s): (1) National Solar Observatory; (2) Indian Institute of Astrophysics, India; (3) Yale University; (4) Stanford University; (5) University Of Colorado

Tuesday May 3, 2011 Poster #50

We use the ring-diagram technique to analyze the sunspots in NOAA active regions 11092 and 11093 during their disk passage during July-August, 2010. The sunspot associated with NOAA 11093 presents a unique case for investigation as it fragments into two spots during its evolution. We will present results comparing the mode parameters and sub-surface properties of these two sunspots using the HMI data processed through the HMI ring-diagram pipeline and compare those obtained with the GONG pipeline. We will then compare results from the analysis of the GONG observations through GONG pipeline and estimate systematic uncertainties. We will further show preliminary results on the measurement of the surface flows using a local correlation technique to examine the fragmentation of the sunspot in NOAA 11093.

Tracked Patches of Solar Activity for HMI

Author(s): Michael Turmon, Xudong Sun, Todd Hoeksema
Affiliation(s): JPL/Caltech and Stanford University HEPL

Wednesday May 4, 2011 Poster #129

We describe an HMI data product consisting of tracked magnetic features on the scale of solar active regions, abbreviated HARPs (HMI Active Region Patches). The HARP data series should be helpful for subsetting individual active regions, for development of near-real-time (NRT) space weather indices for individual active regions, and for defining closed magnetic structures for computationally-intensive disambiguation of vector fields. The data series builds upon the 720s cadence activity masks, produced using the methods of Turmon, Jones, Malanushenko, and Pap (2010), which identify large-scale instantaneously-observed magnetic features. Using these masks as a starting point, large spatially-coherent structures are identified using convolution with a longitudinally-extended kernel on a spherical domain. The resulting set of identified regions is then tracked from image to image. The metric for inter-image association is area of overlap between the best current estimate of AR location, as predicted by temporally extrapolating each currently tracked object, and the set of instantaneously-observed magnetic structures. Once completed tracks have been extracted, they are made into a standardized HARP data series by finding the smallest constant-angular-velocity box, of constant width in latitude and longitude, that encompasses all appearances of the active region. We also discuss open issues in computing active region indices for space weather, and in defining patches with near-zero net flux.

Curvature-induced Intensity Enhancements as Observed by SDO/AIA in Transverse Coronal Loop Oscillations

Author(s): Tom Van Doorsselaere, Marcel Goossens
Affiliation(s): Centre for Plasma Astrophysics, Katholieke Universiteit Leuven, Belgium

Tuesday May 3, 2011 Poster #35

We extend the work by Van Doorsselaere *et al*. (2004) to calculate the eigenfunctions of transverse oscillations in curved coronal loops. We show that the curvature induces coupling between different azimuthal modes, that depends on the length to radius ratio of the loop. For shorter, fatter loops, we find that there is a significant coupling between the transverse mode (displacement) and the sausage mode (intensity increases). This coupling is used to explain the brightenings observed by Aschwanden & Schrijver (2011). Furthermore, the model is used to perform seismology and to measure the observed loop's radius.

Think Scientifically: The Solar Dynamics Observatory's Elementary Science Literacy Program

Author(s): Aleya Van Doren(1), Alison Houpt(2)
Affiliation(s): (1) NASA GSFC, ADNET Sys Inc.; (2) South Mountain Middle School

Tuesday May 3, 2011 Poster #75

The pressure to focus on math and reading at the elementary level has increased in recent years. As a result, science education has taken a back seat in elementary classrooms. The Think Scientifically book series provides a way for

science to easily integrate with existing math and reading curriculum. This story-based science literature program integrates a classic storybook format with solid solar science, to make an educational product that meets state literacy standards. Each story is accompanied by hands-on labs and activities that teachers can easily conduct in their classrooms with minimal training and materials, as well as math and language arts extensions and assessment questions. These books are being distributed through teacher workshops and conferences.

Solar Dynamics Observatory and Solar Probe Plus

Author(s): M. Velli

Affiliation(s): Jet Propulsion Laboratory, California Institute of Technology

Monday May 2, 2011 Poster #2

Solar Probe Plus is a mission to explore the outer solar corona and inner heliosphere which is presently scheduled to launch in 2018, during the second SDO five-year term. SPP, with an orbit remaining inside the ecliptic plane, will rely on other assets, either on Earth or in space, to provide supporting context measurements. While no single remote sensing capability is critical to the success of SPP, the ability to view the solar disk for a significant part of the SPP mission will be required to fully answer its objectives concerning the nature of coronal heating and solar wind acceleration, the source regions of the solar wind, and the origins and acceleration of energetic particles. Although it will reach its innermost perihelion, at 9.5 solar radii, only in 2023, it will achieve three perihelia at 35 solar radii and two at 27 solar radii within a year from launch. Observations of the state of the sun's magnetic field and corona from SDO in conjunction with the in-situ and imaging suite on Solar Probe Plus will provide great opportunities for advancing our understanding on a number of questions, ranging from the structure of the magnetic field and coronal heating in the inner heliosphere to the origins of fast and slow solar wind and their coronal source regions.

On the Fine Structure of Prominences

Author(s): M. Velli(1) and O. Panasenco(2)

Affiliation(s): (1) Jet Propulsion Laboratory, California Institute of Technology; (2) Helio Research

Wednesday May 4, 2011 4:18-4:36pm

Careful observations of filaments, or prominences when observed on the limb, show them to be composed of fine threads of similar dimensions rooted in the chromosphere/photosphere. Observations of counter-streaming motions together with oscillations along the threads provide strong evidence that threads actually trace the magnetic field lines. Here we discuss models of prominence fine-structure emphasizing the role of small scale instabilities driven by gravity, such as rayleigh taylor type interchange modes and/or by velocity in defining the observed vertical motions inside prominences seen on the limb. The discussion of instability naturally leads to a magnetic field model for the observed structures: we compare our model to other recent descriptions of prominence fine structure and discuss the possible role of ion - neutral interaction in the dynamics of prominence threads. We also point to the interest and relevance of measuring the magnetic fields and their topologies inside filaments and filament channels.

A Multi-wavelength Analysis of Active Regions and Sunspots by Comparison of Automatic Detection Algorithms

Author(s): Cis Verbeeck(1), Paul Anthony Higgins(2), Tufan Colak(3), Fraser Thomas Watson(4), Véronique Delouille(1), Benjamin Mampaey(1), Rami Qahwaji(3)

Affiliation(s): (1) Royal Observatory of Belgium, Brussels, Belgium; (2) Trinity College Dublin, Ireland; (3) University of Bradford, UK; (4) University of Glasgow, UK

Wednesday May 4, 2011 Poster #130

Photospheric and coronal properties of active regions are investigated from their emergence to their decay, employing four algorithms developed separately at the Universities of Bradford and Glasgow, the Royal Observatory of Belgium and Trinity College Dublin for the purposes of automated detection of active regions and sunspots at different levels of the solar atmosphere. The algorithms involved in this study are as follows: 1. The Solar Monitor Active Region Tracker (SMART) extracts, characterises, and tracks the evolution of active regions across the solar disk using line-of-sight magnetograms and a combination of image processing techniques. 2. The Automated Solar Activity Prediction code (ASAP) converts continuum images from heliocentric coordinates to Carrington heliographic coordinates, detects and tracks sunspots using thresholding and morphological methods. 3. The Sunspot Tracking And Recognition Algorithm (STARA) is used to detect and track sunspots from continuum images using a technique known as the top-hat transform. 4. The Spatial Possibilistic Clustering Algorithm (SPoCA) is a multi-channel unsupervised spatially constrained fuzzy clustering method that automatically segments solar EUV images into active regions, coronal holes and quiet Sun. We describe the main characteristics of each algorithm along with a detailed comparison of outputs obtained from the analysis of about one month of data from the SOHO-MDI and SOHO-EIT instruments during 12 May - 23 June, 2003. We track two active regions over time to study their properties in detail, and exploit the entire dataset to investigate correlations between physical properties determined by the algorithms. This study allows us to prepare the algorithms in the best possible way for robust analysis of the large SDO data-stream. The detection rates of the algorithms are compared with findings of the National Oceanic and Atmospheric Administration (NOAA) and the Solar Influences Data Analysis Centre (SIDC). By performing an inter-comparison of the algorithms, the physical properties of the solar

features detected are measured at different heights of the solar atmosphere.

Patterns of Nanoflare Heating Exhibited by Active Regions Observed with SDO/AIA

Author(s): Nicholeen M. Viall and James A. Klimchuk
Affiliation(s): NASA Goddard Space Flight Center

Tuesday May 3, 2011 4:18-4:36pm

It seems largely agreed that many coronal loops---those observed at a temperature of about 1 MK---are bundles of unresolved strands that are heated by storms of impulsive nanoflares. The nature of coronal heating in hotter loops and in the very important but largely ignored diffuse component of active regions is much less clear. Are these regions also heated impulsively, or is the heating quasi steady? The spectacular new data from the Atmospheric Imaging Assembly (AIA) telescopes on the Solar Dynamics Observatory (SDO) offer an excellent opportunity to address this question. We analyze the light curves of coronal loops and the diffuse corona in 6 different AIA channels and compare them with the predicted light curves from theoretical models. Light curves in the different AIA channels reach their peak intensities with predictable orderings as a function the nanoflare storm properties. We show that while some sets of light curves exhibit clear evidence of cooling after nanoflare storms, other cases are less straightforward to interpret. Complications arise because of line-of-sight integration through many different structures, the broadband nature of the AIA channels, and because physical properties can change substantially depending on the magnitude of the energy release. Nevertheless, we show that the light curves exhibit predictable and understandable patterns consistent with nanoflare storm heating. Lastly, we take full advantage of the combined continuous coverage and high temporal and spatial resolution of SDO/AIA by expanding on these event studies and examining the statistical time-lag patterns exhibited by entire active regions. Our results indicate that nanoflare heating is ubiquitous.

Reconstruction of the Solar Spectral Irradiance Evolution: New Insights from SDO/HMI Observations

Author(s): L.E.A. Vieira, T. Dudok de Wit, M. Kretzschmar, G. Cessateur, L.A. Da Silva
Affiliation(s): CNRS and University of Orleans

Thursday May 4, 2011 11:12-11:30am

The neutral and ionized components of the highly coupled Earth's atmospheric/oceanic system are affected by the variability of the solar electromagnetic and corpuscular emission on time-scales from hours to millennia. However, there are large uncertainties on the local and global impact of the solar variability because reliable, continuous observations of solar and geophysical parameters are available only for the last three decades, which is the period that a large impact of human activities on Earth's system is observed. Among several heliophysical quantities, the evolution of the solar total and spectral irradiance is a key element to understand the evolution of the Earth's system. Empirical and physics-based models have been employed to assess the evolution of the solar irradiance through the Holocene. These models are based on the assumption that the evolution of the solar irradiance is related to the evolution of the magnetic structure of the solar atmosphere. In this way, the quantification of magnetic flux emerging in active and ephemeral regions through the solar cycle is necessary to model the long-term evolution of the solar irradiance. While the evolution of active regions has been well documented, the evolution of small bipolar regions is still not clear. The high resolution observations of solar surface magnetism provided by the HMI instrument on board of SDO spacecraft provide an unprecedented opportunity to address this problem. Here, we present our preliminary results on the detection of active and ephemeral regions, which are employed to reconstruct the solar irradiance. The uncertainties and operational issues are also discussed in details. An online prototype of the near real-time spectral reconstruction is available at http://lpc2e.cnrs-orleans.fr/~soteria/. This work is supported by the European Commission's Seventh Framework Programme(FP7/2007-2013) under the grant agreement n° 218816.

Analyses of Active Region 11117 Based on SDO/HMI Observations Using a Three-dimensional Magnetohydrodynamic Data-driven Active Region Evolution Model

Author(s): Aihua Wang(1), S. T. Wu(1) and Yang Liu(2)
Affiliation(s): (1) CSPAR, Univ. of Alabama in Huntsville, Huntsville, AL, USA; (2) WW Hansen Experimental Physics Laboratory, Stanford University, Stanford, CA, USA

Tuesday May 3, 2011 Poster #42

We have employed a three-dimensional magnetohydrodynamic Data-Driven Active Region Evolution Model to analyze the physical properties of AR1117 observed by SDO/HMI. In this preliminary report, we present the evolutions of the magnetic non-potential parameters and current helicity for this active region. From the physical properties, we expect to reveal the initiation and mechanisms of solar flare and CME.

Investigating Coronal Heating with Hinode and SDO

Author(s): Harry Warren
Affiliation(s): NRL

Tuesday May 3, 2011 Poster #65

The coronal heating problem is one of the great unsolved problems in solar physics. The analysis of recent observations from EIS and XRT on Hinode and AIA on

SDO has indicated that the high temperature (~4 MK) loops the are found in the core of a solar active region are close to equilibrium. We have found several examples of active regions where the warm emission (~1 MK) expected from cooling loops is very weak relative to the predictions of simple hydrodynamic models. This suggests that these loops are heated on time scales much shorter than a characteristic cooling time. In this poster we will review the evidence for high-frequency heating and give an update on efforts to model an active region volume using hydrodynamic simulations.

Confessions of a Middle Child: Solar Physics, the Solar EUV Irradiance, and the Earth's Upper Atmosphere

Author(s): Harry Warren
Affiliation(s): NRL

Wednesday May 4, 2011 8:30-9:00am

The solar EUV irradiance is fundamental in determining the state of the Earth's upper atmosphere and affects the performance of many systems that are important to human activity, such as spacecraft in low Earth orbit. The problem of understanding the solar EUV irradiance and its variability is, however, often viewed as the "middle child" of heliospheric physics. Irradiance observations have traditionally lacked the spatial, spectral, and temporal resolution to be of interest to many solar physicists, and the problems associated with determining the magnitude and origin of solar irradiance variability often seem obscure to researchers studying atmospheric processes. The extraordinary capabilities of the instruments on SDO promise to bridge the gap between solar and atmospheric physics by allowing us to track the flow of mass and energy through the heliosphere at very high temporal and spatial resolution. Solar flares, for example, are a potentially rich source of information on how small-scale processes in the solar atmosphere such as magnetic reconnection are coupled to the Earth's upper atmosphere. In this talk I will discuss the interrelationships between high resolution solar data and EUV irradiance observations. In particular I will discuss how solar data can be used to infer the solar irradiance and how irradiance observations taken during solar flares can be used to study the properties of magnetic reconnection.

SDO Citizen Scientists; The Camilla Space Weather Project

Author(s): Martha Wawro(1), Aleya Van Doren(1), Kevin Addison(1), Romeo Durscher(2)
Affiliation(s): (1) NASA-GSFC; (2) Stanford University

Tuesday May 3, 2011 Poster #76

After the launch of the Solar Dynamics Observatory (SDO) in February of 2010 and the subsequent release of huge amounts of data to public venues there arose a need to educate the public not just about the existence of this data, but also how to utilize this data in a meaningful way. With a large formal citizen science project in the works but at least a year in prior to completion, the SDO education and public outreach (E/PO) team developed an interactive interface for the public and classrooms to use and analyze SDO data to make space weather predictions and to submit this data analysis. The Camilla Space Weather Project and the SDO Space Weather Month bring together a menagerie of disparate Space Weather E/PO projects around the launch of Camilla in a high altitude weather balloon. This project asks members of the public and classrooms to interact with SDO and other solar mission data in manner similar to solar scientist to make their own space weather predictions, with the goal of not only making the public more aware of SDO and SDO data, but to also make them more aware of how the data is used to monitor space weather events and the impact that space weather events can have on life on earth. The interaction of the general public with real data also creates a feeling of inclusion on the SDO team and ownership in the project, which will help any future citizen science project by creating a ready pool of participants.

Exploration Station and AstroZone; Where the Public Meets Science

Author(s): Martha Wawro(1), Emilie Drobnes-Etesi(1), Aleya Van Doren(1), Romeo Durscher(2)
Affiliation(s): (1) NASA-GSFC; (2) Stanford University

Tuesday May 3, 2011 Poster #77

Exploration Station and AstroZone are public hands on events organized and lead by the SDO E/PO team. Exploration Station is a public event held prior to the American Geophysical Union (AGU) annual meeting each year and is a joint venture between the AGU and NASA's Solar Dynamics Observatory (SDO). AstroZone is a similar event held prior to the AAS biannual meetings. Many members of the general public attend these events including many families with children, along with Union and Society members respectively. These events have inter-agency participation and support and have had a large impact on the members of the public that attended them. Exploration Station 2010 is the first such event that was fully evaluated and some of the results of this evaluation will be presented with this poster including the impact on attendees behaviors and the subjects and exhibitors that had the biggest impact on the attendees. This poster will also talk about what we will be doing in the future and how the SDO science community can be an important part of future events.

Studying the Characteristics of CMEs Using Combined Imaging and In-situ Data from STEREO, SOHO and other L1 spacecraft, SMEI and SDO

Author(s): D. F. Webb [1], M. M. Bisi [2], C. A. de Koning [3], R. A. Harrison [4], T. A. Howard [5], B. V. Jackson [6], J. C. Johnston [7], E. Kilpua [8], T. Kuchar [1], C. Moestl [9], J. Tappin [10]

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Monday May 2, 2011 Poster #4

Despite the extended low solar activity period continuing though the commencement of STEREO observations in 2007, there have been 20-30 coronal mass ejections (CMEs) observed near the Sun by one or both STEREO (SECCHI) instruments, and/or SOHO (LASCO) telescopes, that have yielded in situ "ground truth" data when passing over one of the STEREOs or Earth-based sensors. CME source regions on the Earth-facing Sun have been well observed by SOHO and Hinode and, since last April, by the Solar Dynamics Observatory. The heliospheric propagation of these CMEs has also been observed by the heliospheric imagers (HIs) on STEREO and/or the Earth-orbiting Solar Mass Ejection Imager (SMEI). HI and SMEI observations of the same ICMEs provide complementary information. This class of events can provide important information on the characteristics of the geometry, propagation and internal structure of CMEs. In addition, these data sets can be used for forecasting space weather. Within the last year, group predictions based on several techniques have been made for a few events, including the recent February X-flare/CME. We summarize these results in terms of understanding the characteristics and propagation of CMEs and discuss the ramifications for space weather forecasting.

The AIA Temperature Data Product

Author(s): M.Weber(1), P.Boerner(2), and K.Schrijver(2)
Affiliation(s): (1) Harvard-Smithsonian Center for Astrophysics; (2) Lockheed-Martin

Monday May 2, 2011 2:20-2:38pm

The Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO) has seven EUV channels, six of which are dominated by Fe lines and measure the optically-thin part of the solar atmosphere. The instrument's spectral responses for these channels are overlapping functions of temperature and can be used to invert the intensity data for emission measure distributions. The AIA Team is developing a data product pipeline which will regularly produce emission measure maps in multiple temperature ranges, and techniques have been developed to perform rapid inversions for the pipeline (on the order of a few seconds per image set). I will describe this data product, give an update on its progress, and identify areas of remaining difficulties. This work is supported under AIA subcontract SP02H1701R from Lockheed-Martin.

Using HMI to Understand the Physics of Flux Cancellation

Author(s): Brian Welsch, George Fisher, Xudong Sun
Affiliation(s): Space Sciences Lab, UC-Berkeley; Space Sciences Lab, UC-Berkeley; HEPL, Stanford University

Tuesday May 3, 2011 Poster #53

Cancellation of magnetic flux in magnetograms has been defined in observational terms as "the mutual apparent loss of magnetic flux in closely spaced features of opposite polarity." Physically, this removal of flux could correspond to one of three mechanisms: (i) the emergence of U-shaped magnetic loops, (ii) the submergence of Omega-shaped loops, or (iii) reconnection in the magnetogram layer. Evidence has been reported for all three of these mechanisms, but does one predominate? Does most canceling flux enter the outer solar atmosphere, or submerge into the interior? Answers to these questions will improve our understanding of both the solar-cycle and quiet-Sun dynamos, as well as the origins of structures that erupt in coronal mass ejections (CMEs). We can investigate cancellation mechanisms at work in an active region's magnetic fields using time-averaged Doppler shifts along polarity inversion lines (PILs) of the line-of-sight (LOS) magnetic field near disk center. Along these PILs, the LOS component of the magnetic field vanishes, so LOS flows inferred from Doppler shifts are perpendicular to the magnetic field. If the evolution is ideal, such flows imply the transport of magnetic flux across the atmospheric layer imaged in the magnetogram. As a preliminary step in our study, we present an innovative method to remove biases in the measured Doppler velocities due to offset in the line-center position, which might arise from a well-known correlation between brightness and blueshifts in the convecting photospheric plasma. In cases with significant discrepancies between flux cancellation rates separately inferred from (1) changes in LOS flux near canceling PILs and (2) combined Doppler velocities and transverse field strengths along PILs, we can characterize departures from ideal evolution in terms of an effective magnetic diffusivity, which can be evaluated from the data.

Time-series Analysis of Supergranulation Characteristics Using SDO/HMI Dopplergrams

Author(s): Peter E. Williams, W. Dean Pesnell
Affiliation(s): ORAU/NASA-GSFC, NASA-GSFC

Tuesday May 3, 2011 Poster #33

Supergranulation has been shown to have strong divergent horizontal flow components within Doppler data. These play a role in solar magnetic field structure by advecting field lines to supergranule boundaries, after they have been

dragged to the surface by the related but much weaker, radial flows, where their congregation is observed in Ca II K images as the chromospheric network. We have previously studied characteristics of supergranulation, such as their typical sizes, velocities and lifetimes, using SOHO/MDI Doppler data. We have found that the evolution of some of these characteristics exhibits oscillatory behavior on the order of 3-5 days. We have performed time-series analyses on HMI data and compared the results to those derived from contemporaneous MDI data. We find a similar time-dependence in the characteristics that suggest a solar origin as opposed to any instrumental influences.

AIA Plate Scale Analysis

Author(s): Henry "Trae" Winter and Yingna Su
Affiliation(s): SAO

Wednesday May 4, 2011 Poster #119

In order to make accurate measurements of solar phenomena, the plate scale of the observing telescope must be known. While a plate scale can be determined from detailed ground measurements of a telescope's focal length and physical pixel size, the forces at launch and the harsh space environment require that plate scale calculations be verified on orbit. The process of verifying plate scales on orbit is not trivial and usually is limited to measurements relative to other instruments. The technique of Auchère *et al*. (2000) allows us to determine the on-orbit plate scale of each AIA telescope assembly (ATA) during offpointing manuvers. The results of this plate scale analysis and their error bars will be presented with comparisons to results from other methods of plate scale determination.

Adding the Flare to Nano-Flare Loop Heating Models

Author(s): Henry "Trae" Winter and Chester Curme
Affiliation(s): SAO, Middlebury College

Tuesday May 3, 2011 4:00-4:18pm

Recent simulations by Winter and Curme (2009 & 2010), using the HyLoop hybrid modeling suite, showed that adding nonthermal particles to the standard nanoflare heating model of a single solar coronal loop drastically altered how and where energy was deposited in the loop plasma. The simulations also showed that slight tapering angles had a large effect on the deposition of energy due to magnetic mirroring and this had obvious consequences for the loop temperature and pressure. In this work we simulate a bundle of strands that are sub-AIA resolution to create an observed "loop". These strands undergo nanoflare heating that generate distributions of nonthermal particles. The observational signatures of this form of heating with nonthermal particles are shown by synthesizing images from AIA telescopes onboard SDO in order to directly compare simulated results to observations. This work is supported by NASA grant NNX09AB18G S01 and Chester Curme is supported by NSF grant ATM-0851866.

EVE Data Access

Author(s): Donald Woodraska, Mike Dorey, Tom Woods, Frank Eparvier, Andrew Jones
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Wednesday May 4, 2011 Poster #117

Normal science operations for the EUV Variability Experiment (EVE) instrument on NASA's Solar Dynamics Observatory began on April 30, 2010. Quick-look data products were immediately available. In February 2011 higher quality calibrated version 2 data products were publicly released. We present the tools for accessing the EVE data products including: direct HTTP navigation of data directories, an interactive product search tool, a web service supporting automated downloads, and an interactive tool to support online plotting and downloading of data.

The 2011 Valentine Storm as Seen by SDO

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Monday May 2, 2011 4:00-4:18pm

The solar storms on February 13-19, 2011 have been the most intense solar activity during solar cycle 24. Prior to this 2011 Valentine Storm, the last large (X class) flare observed was on December 13, 2006 during solar cycle 23. This one week of solar storms had more than 50 flares larger than C2 class and exceeds the number of flares seen so far during the SDO mission (with normal operations starting in May 2010). SDO continuous observations of the Sun with high spatial resolution with HMI and AIA and high spectral resolution with EVE are providing new insights into the many processes of the dynamic Sun. Some of the SDO results of the larger solar storms during this 2011 Valentine storm will be presented along with a comparison to similar solar storm periods during the previous solar cycle 23. While this 2011 Valentine storm is a significant increase of activity for solar cycle 24, the 2011 solar activity is still very low compared to the rising phase of solar cycle 23.

Radiative 3D MHD Code for Realistic Simulations of Turbulent Dynamics of the Solar Convection Zone and Atmosphere

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Through their unique capabilities, the recent space missions SDO and Hinode are providing extremely detailed data on the solar surface and atmosphere. However, the complexity of the observed phenomena makes interpretation and understanding of the underlying physical processes very difficult. To aid in this interpretation, we have developed a

3D radiative MHD code, "SolarBox", which provides realistic simulations of the turbulent behavior of the upper layers of the convective zone and the lower atmosphere, both in the quiet Sun and in active regions. The code uses a realistic tabulated EOS, opacity-binned radiative transfer between fluid elements, and subgrid scale (Large Eddy Simulation) MHD turbulence models. The SolarBox code has been successfully used for studying various solar problems, such as Evershed flows, acoustic wave excitation, magnetic structure formation, and others. In combination with a line formation program, the code provides synthetic Stokes profiles for interpretation and calibration of Hinode and HMI data. Future plans include the development and implementation of non-LTE radiative transfer models for accurate modeling of chromospheric phenomena.

Solar Irradiance Reconstructions Using HMI Data

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Tuesday May 3, 2011 Poster #67

Variation of solar irradiance is an important candidate for driving global climate change. Measurements are available since 1978, i.e. for nearly 3 solar cycles. Although a variety of models have been proposed to explain the irradiance variations, the assumption that these are caused by the magnetic field at the solar surface has been particularly productive. However, the successful modelling of the solar irradiance under this assumption requires the availability of high-quality magnetograms. Up until 2010 the best such data set was that provided by MDI on SOHO. This has now been surpassed by HMI on SDO in both spatial resolution and noise level. Hence the use of SDO data for solar irradiance modelling represents the next step in order to a) continue the irradiance modelling in the coming years b) improve the models and provide better tests of the underlying assumption (thanks to the fact that HMI samples a larger fraction of the solar magnetic flux). Here we describe the steps carried out to apply the SDO data to solar irradiance reconstructions and present first results.

Signatures of Small-scale Magnetic Field Emergence as Seen from the New Solar Telescope in Big Bear

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Monday May 2, 2011 Poster #16

Increased resolution of solar telescopes allows us to study emerging small-scale magnetic fields in unprecedented detail. First light Hinode magnetograms showed evidence of both horizontal and line-of-sight field being constantly brought to the solar surface by solar convection motion. What are the signatures of these fields in the photosphere, if any? The largest aperture ground-based solar telescope, the New Solar Telescope (NST) of Big Bear Solar Observatory now allows us to address many important issues of coupling between the photosphere and chromosphere by means of simultaneous observations of photospheric granulation with well-resolved bright points and associated dynamics in the low chromosphere, as seen in the H-alpha spectral line. Excellent seeing conditions, augmented with an adaptive optics system and speckle-reconstruction applications produce diffraction limited images. We examine NST granulation and Halpha images co-temporal with SDO, Hinode and BBSO/IRIM magnetograms. Our main finding is that emerging magnetic flux leaves clear footprint in solar granulation. Moreover, the granulation responds to the emerging flux much earlier that it appears in magnetograms. NST granulation images also reveal that various bright points as well as bright granular lanes may form and evolve within a granule. These newly detected features are believed to be associated with small-scale magnetic fields, which may be too weak to be detected by SDO and Hinode magnetograms.

On the Origin of Intergranular Jets

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Tuesday May 3, 2011 Poster #66

Goode *et al*. discovered tiny jets originating in the ubiquitous inter-granular (IG) lanes surrounding individual granules. In the present work we continue to explore the nature of these IG jets and seek for the associated photospheric dynamics that may be at their origin. The study is based on the photospheric TiO broadband (0.3 nm) filter data acquired with the 1.6 m New Solar Telescope (NST) of operating at the Big Bear Solar Observatory. The data set also included NST off-band Ha images collected with a Zeiss Lyot filter (passband of 0.025 nm). We report the following. The IG jets tend to be associated with fragmentation of a granule, in particular, formation and evolution of a bright granular lane (BGL). General appearance and evolution of a BGL event allowed us to identify it as a vortex tube recently discovered by Steiner *et al*. BGL signatures may reach the lower chromosphere and can be detected in off-band Ha images. Simulations also indicate that vortex tubes are often associated with small-scale magnetic fields. We this speculate that the IG jets detected in NST data may results form interaction between the turbulent small-scale fields and the larger scale fields existing in the intergranular lanes.

The Global Character of the 2010.08.01 Earth-directed Coronal Mass Ejection and the Cause of the Associated Great Sympathetic Solar Storm

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The simultaneous and continuous near-global observations of SDO/AIA and STEREO/COR1A reveal a great sympathetic solar storm on 2010/08/01. This storm consists of near-synchronous, wide-separated active-region flares, quiet-Sun filament eruptions, and coronal mass ejections. It is found that all events of substantial coronal activity are connected by a wide-ranging system of magnetic fault, such as separatrices, separators, and quasi-separatrix layers [Schrijver and Title, 2011]. Based on observations of SOHO/LASCO, STEREO/COR1 and COR2 we determine the size of the associated Earth-directed CME to be more than 140 degrees which is greater than the upper width limit of limb CMEs [Burkepile *et al*., 2004]. It is found that all substantial coronal activity and associated magnetic fault zone are located within a great coronal closed region with 5 bipoles sandwiched between opposite-polarity coronal holes [Zhao and Webb, 2003]. Based on this finding and the observation of SDO/HMI, the cause and underlying trigugger of the 2010.08.01 great sympathetic solar storm are discussed.

The Many Spectra of the HMI Time-Distance Analysis Pipeline

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The Helioseismic and Magnetic Imager onboard Solar Dynamics Observatory provides continuous high-resolution observations of solar oscillations over the entire disk. Time-distance analysis pipeline has been developed to perform a near real-time analysis of these observations, and provide full-disk subsurface flow fields and wave-speed perturbation maps every 8 hours. The results from the pipeline are suitable to study supergranulation, active regions and their evolution, solar interior flows, solar interior rotational rate, and meridional flow speed. With nearly one year observation available, we present our findings from the pipeline analysis.

Analysis of *k*-Ω and Time-Distance Diagrams of a Sunspot

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Power spectrum diagram, or *k*-Ω diagram, obtained from the solar oscillation observations, is useful in deriving solar atmosphere stratification, interior structures, and dynamics. The high spatial resolution and high cadence observations by HMI have enabled us to obtain a *k*-Ω diagram using only oscillation signals inside a sunspot. It is found that the f-mode ridge is greatly suppressed in power and shortened in length, and p-mode ridges are relatively shifted to low-*k* and high-ν areas. The time-distance diagram is also obtained using only oscillation signals inside this sunspot. It is found that for most acoustic travel distances, the travel times are shorter than those obtained from quiet-Sun regions. Both the *k*-Ω and the time-distance diagrams carry substantial information of the sunspot interior structures and magnetic field.